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Agricultural Memorandum No. 1089 (Amended Text + FIG 9)

Assessment of Forecast T-sums for 1987 Using Model Output Statistics

by M J Lee and C J Penn

SUMMARY

The accuracy with which model output statistics (MOS) can be used to forecast weekly T-sums between 1 January and 30 April 1987 is assessed. Comparisons are made with raw model output, persistence and climatology, with MOS giving the lowest RMS errors of between 5 and 10 degree days in a week. This translates into MOS being 3 days or less out in the prediction of the date of T-sum 200 in 81% of T-sum squares covering Great Britain, and effectively a week or less out for all squares except one where the prediction occurred during a cold spell.

1. Introduction

T-sums (or accumulated daily temperatures above a base of zero C from 1 January) are used for a number of specific agricultural purposes as well as to provide a quantitative indication of seasonal temperature. In January 1987 the Met Office started its trial T-sum forecast service at the request of UKF Fertilisers Ltd. Tabulated T-sum forecasts for 7 days ahead were updated daily on FARMLINK/PRESTEL and weekly in Farmers Weekly (see examples of each in Figure 1). The T-sums are areal averages for 126 squares on a 50 x 50 km grid covering Great Britain (see Figure 2). The grid is thus slightly larger than that used by MORECS (the Met Office Rainfall and Evaporation Calculation System).

MOS were used to calculate maximum and minimum temperatures each day for up to 6 days ahead. The calculations were made for about 140 stations in Great Britain and the station values were interpolated onto the 50 x 50 km grid. From these temperatures, daily averages were produced and added together to produce T-sums unless the average temperature was negative, in which case no increment was made. Persistence was used for the seventh day. Thus the T-sum for day n is

$$\sum_{m=1}^{n-7} \Delta T_m \quad + \quad \sum_{m=n-6}^{n-1} \Delta T'_m \quad + \quad \Delta T'_{n-1}$$

where ΔT_m is the increment in temperature for day m and $\Delta T'_m$ is the increment in MOS temperature forecast for day m. T-sums for coastal areas were also calculated in the relevant squares. A diagram of the procedure is given in Figure 3.

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The farming community gives particular attention to the date at which T-sum 200 is reached. On the basis, primarily, of work by Dutch agronomists UKF consider this to be the optimum time for applying nitrogen fertilizer to grassland. Since this was the date of interest to our commercial customer the analysis concentrated on how well T-sum 200 was forecast. However, if this were the only application then a very legitimate question would be 'why issue forecasts before T-sum 200 is on the horizon?' Apart from the understandable wish of UKF to interest potential customers there are much wider potential applications for accurate prediction of accumulated temperature in agriculture. Models that predict the development and growth of crops, or of the insects and pathogens that live in or on these crops are of great potential value in crop management and protection. Accumulated temperature is often the basic input to these models and values from any base temperature or start date would be easy to include. This particular trial of T-sum predictions can be considered as the first step in establishing the potential usefulness of forecast accumulated temperature in agriculture.

2. Analysis

The analysis has been carried out on a weekly and a daily basis to cover the two commercial outlets. For comparison with the MOS forecast, weekly forecasts based on printfile model output (T^*), persistence and climatology have also been prepared. (For example, the T-sum calculated by the climatology method for day n is

$$\sum_{m=1}^{n-7} \Delta T_m \quad + \quad 7(\Delta T_{n-6}^{cl})$$

where ΔT_m^{cl} is the increment in temperature for day m derived from climatological monthly averages.) It was not feasible to use subjectively produced forecasts in the comparison.

In Figure 4 the four methods of prognosis (MOS, T^*, persistence and climatology) were regressed against the actual value of weekly T-sum for the period 1 January-30 April 1987. There is considerably less scatter in the plot of T-sum (MOS) versus T-sum (actual). The statistics are summarised in Table 1. T-sums tended to be overestimated in all four methods, particularly the printfile and climatological forecasts. Printfile temperatures have a bias of about 3 degree days, or nearly 20 degree days per week. MOS reduce the bias but, as the method is based on monthly updates of the statistics, there is a residual monthly bias. MOS temperatures were generally overestimated during January to March and underestimated in April. As expected, the climatological T-sums were overestimated due to the colder than average months of January and March, in spite of a warmer than average April.

Comparing the weekly RMS errors for these forecasts, shown in Table 2, the MOS method is, in general, much better than the others, particularly during the period of abnormally low temperatures in weeks 2-5 (8-29 January 1987). Examples of the accuracy of weekly MOS T-sums are given in Figure 5. The T-sum predictions during a period of marked change in the weather between weeks (such as weeks 1 to 2 and weeks 6 to 7) generally are comparable in quality, if not better than the predictions during conditions of steady change (such as weeks 12 to 17). The RMS errors for the MOS method are highest for weeks 12 and 17, due to underestimates in the forecast in central and southern England where conditions were warmer than average.

RMS errors in the weekly MOS and persistence T-sums are displayed for each square in Figure 6. It can be seen that the MOS error, which varies between 4.5 and 10.6 degree days, is about half to two thirds of the persistence value in a majority of squares.

Figure 7(a) illustrates the errors in MOS T-sum 200 predictions as perceived by a daily FARMLINK viewer. Figures 7(b) for T^*, 7(c) for persistence and 7(d) for climatology have been included for comparison. Figure 8(a) illustrates the weekly errors in MOS T-sum 200 as perceived by a Farmers Weekly reader and figures 8(b), (c) and (d) display those for the other forecast methods.

It should be noted when looking at these diagrams that no forecast can be more than one week (or 7 days) late in predicting T-sum 200, because of the way in which the T-sums are updated with actual data. So a -1 on the weekly maps indicates that the forecast method has failed to predict T-sum passing over 200 before it actually happens. When the errors are positive, ie when T-sum 200 has been forecast but did not occur, the forecast method has 'another chance' to get it right (see Figure 9).

The accuracy of the T-sum 200 daily predictions is shown in Figure 10. The success of the MOS method in forecasting the day of T-sum 200 correctly is double that of other methods. T-sum 200 was forecast to an accuracy of ±3 days in 81% of squares and to an accuracy of ±7 days in 90% of squares. Forecasts using climatological temperatures tended to be too late, and those by the printfile temperatures tended to be too early. Nearly a third of T-sum 200 dates forecast by persistence were more than 10 days too early.

The accuracy of the weekly predictions is summarised in Table 3. The MOS method forecast the week of T-sum 200 correctly in 80% of cases compared with under 60% of cases for the other methods. The persistence forecasts tended to be too late and more than half the climatology forecasts were a week out, but there are no cases where the predictions were more than one week too early. The printfile forecasts tended to be too early, with 5 cases where the forecast was 2 weeks too early. There are also 5 cases where the MOS predictions were 2 weeks early. Adopting a different day of the week for the issue of the weekly forecasts from that demanded by the publishing constraints of Farmers Weekly for the forecasts there are no cases where they were more than one week too early (see Table 3 and Figure 11).

Returning to the Farmers Weekly MOS forecasts, of the 5 squares where T-sum 200 was predicted 2 weeks early, 4 were effectively one week too early since the actual T-sum was very close to 200 in the preceeding week. All 5 forecasts were made in week 9 during a cold spell. Of the 13 squares where the MOS predictions were a week early, in all but 3 cases the actual T-sum reached more than 190 degree days. There are only 6 squares where

T-sum 200 was forecast too late and of these forecasts half were very near misses (by less than 0.5 degree days) and all were greater than 195 degree days.

Figure 12 shows the equivalent errors on the MOS predictions of T-sum 200 for coastal squares. The results are very similar to the predictions of non-coastal T-sums. For 81% of squares there was not more than a three day difference between the forecast and actual T-sum 200 and none was more than one week out.

3. Discussion and Conclusions

Forecasts by the MOS method are clearly better than the others, both in a comparison of RMS errors and in predicting the date when the T-sum passes through 200 degree days.

The cases where the MOS T-sum 200 was forecast a week too late were not seriously misleading as the difference between the forecast and the actual T-sums was very small. Similarly for most squares where the forecast was too early the difference was effectively less than a week. In only one case would the user have been apparently seriously misled by a prediction 2 weeks too early and, since the spreading of fertilizer is not advised in very cold conditions, as applied in this case, the practical impact would have been minimal. Had the Farmers Weekly taken forecasts issued on a different day of the week this error would not have arisen. The problem is unavoidable if forecasts are provided only once a week, but in spite of this the MOS forecast published in Farmers Weekly was out by a week or less in all but one square.

The daily predictions on FARMLINK provided the user with a more reliable forecast than that in Farmers Weekly as succeeding predictions reinforced or negated those of the previous days. In 81% of the squares the T-sum 200 was forecast with an accuracy of ±3 days. Compared with the previous year's T-sum analysis (see Agricultural Memorandum No. 1081) the predictions for 1987 were not as successful on a daily basis (92% of squares were successfully predicted to within 2 days in 1986) but fared better on a weekly basis. These differences are probably an artifact of the weather regime rather than any reflection on the MOS method.

An indication of the climatological T-sum for each square would be helpful to the user particularly in cases where T-sum 200 is forecast during a cold spell or not forecast during a warm one.

KEY WORDS: Model Output Statistics, T-sums

Any comments or suggestions on this paper should be referred to

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Table 1

Summary of regressions against T-sum (actual) for period 1 January-30 April 1987

	Intercept	Slope	RMS error	R^2
T-sum (MOS)	5.5 ± 0.2	0.78 ± 0.01	6.5	0.88
T-sum (persist)	2.1 ± 0.4	0.84 ± 0.01	12.0	0.72
T-sum (climate)	19.3 ± 0.3	0.43 ± 0.01	9.4	0.52
T-sum (printfile)	13.3 ± 0.3	0.73 ± 0.01	9.4	0.76

Table 2

RMS errors on weekly forecast T-sums for period 1 January-30 April 1987

Week	End Date	MOS	Persistence	Climatology	Printfile
1	7 Jan '87	4.5	6.5	4.4	4.4
2	14 " "	1.4	5.2	6.6	10.8
3	21 " "	2.7	-	9.2	11.1
4	28 " "	4.3	12.0	7.7	7.6
5	4 Feb "	2.1	6.3	6.1	5.6
6	11 " "	3.5	7.7	5.3	6.3
7	18 " "	4.2	4.1	5.3	9.6
8	25 " "	4.5	3.8	7.0	5.1
9	4 Mar "	2.7	6.2	3.8	4.9
10	11 " "	3.5	6.5	5.8	5.7
11	18 " "	3.0	5.2	4.2	6.5
12	25 " "	4.9	3.0	3.7	9.0
13	1 Apr "	2.8	7.0	4.0	6.2
14	8 " "	2.8	5.9	2.9	3.9
15	15 " "	3.7	7.3	2.8	5.3
16	22 " "	4.6	6.5	4.6	7.1
17	29 " "	5.6	6.5	5.1	10.3

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Table 3

Summary of errors in weekly forecasts of T-sum 200 for 1987

method	number of cases			
	1 wk late	correct	1 wk early	2 wks early
MOS (a)	8	99	19	-
(b)	6	102	13	5
Printfile	1	64	56	5
Persistence	48	73	5	-
Climatology	35	61	60	-

(a) weeks starting from 1 January 1987

(b) week starting from 4 January 1987 as for Farmers Weekly

FIGURE 1(a)

EXAMPLE OF T-SUM SERVICE ON FARMLINK

```
                    FARMAID - DAILY T SUMS
          ACTUAL & FORECAST VALUES FROM JAN 1ST : SOUTHEAST REGION

          ACTUAL TO 01/03/87 (D)    FORECAST FOR D+7      SQUARE      HEIGHT
SQUARE NO     INLAND    COASTAL      INLAND    COASTAL     HEIGHT    CORRECTION

   97         153.3                  186.0                  127        23.4
   98         151.5                  183.4                  103        22.8
  105         162.8                  195.7                  132        23.4
  106         172.5                  205.8                   83        24.0
  107         209.7                  251.6                   58        28.2
  108         182.3      182.8       214.9     211.6         48        26.4
  109         172.2      184.8       201.5     216.1         28        27.0
  114         197.9                  237.3                   69        28.2
  115         189.0                  225.4                   84        25.2
  116         174.0      189.8       207.5     222.0         61        25.8
  117         177.5      211.2       208.0     228.9         48        26.4
  118         173.0      210.6       201.4     226.9         63        26.4
  124         222.2      246.4       263.3     289.0         36        31.8
  125         207.0      209.8       246.2     250.6         25        30.6

PRESS PF6 TO CHOOSE ANOTHER DATE/REGION, PF2 FOR MAIN MENU, OR PF4 TO QUIT
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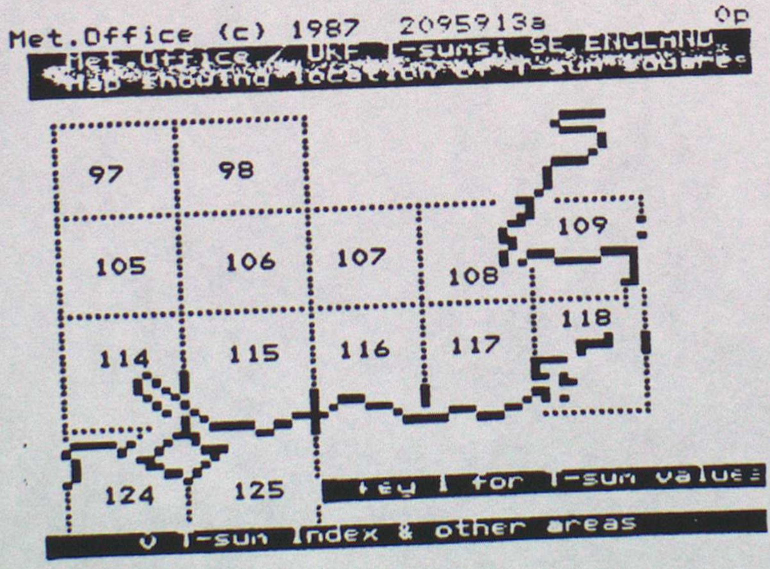


Met.Office (c) 1987   2095913a   0p

Met.Office / UKF T-sums: SE ENGLAND

Map showing location of T-sum squares

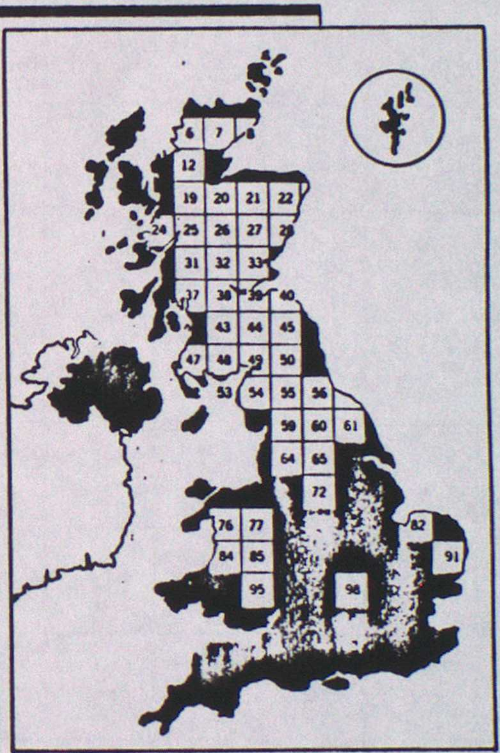
key 1 for T-sum values

0 T-sum Index & other areas

FIGURE 1(b) EXAMPLE OF T-SUM SERVICE IN FARMERS WEEKLY

T-SUM DATA TO 22.3.87

Sq	T-sum	Sq	T-sum	Sq	T-sum	Sq	T-sum	Sq	T-sum	Sq	T-sum	Sq	T-sum	Sq	T-sum
1	X	18	X	35	X	52	X	69	X	86	X	103	X	120	X
2	X	19	112	36	X	53	166	70	X	87	X	104	X	121	X
3	X	20	107	37	187	54	116	71	X	88	X	105	X	122	X
4	X	21	100	38	176	55	191	72	156	89	X	106	X	123	X
5	X	22	187	39	174	56	191	73	X	90	X	107	X	124	X
6	194	23	X	40	176	57	X	74	X	91	194	108	X	125	X
7	180	24	187	41	X	58	X	75	X	92	X	109	X	126	X
8	190	25	108	42	X	59	133	76	180	93	X	110	X	127	X
9	X	26	72	43	114	60	175	77	189	94	X	111	X	128	X
10	X	27	75	44	91	61	184	78	X	95	196	112	X	129	X
11	X	28	184	45	140	62	X	79	X	96	X	113	X	130	X
12	126	29	X	46	X	63	X	80	X	97	X	114	X	131	X
13	X	30	X	47	196	64	172	81	X	98	194	115	X	132	X
14	X	31	113	48	162	65	186	82	199	99	X	116	X	Shetland	
15	X	32	94	49	174	66	X	83	X	100	X	117	X		X
16	X	33	184	50	129	67	X	84	193	101	X	118	X		
17	X	34	X	51	X	68	X	85	181	102	X	119	X	X=200+	



T-sum end is nigh . . .

SOME 66% OF MAINLAND BRITain and all coastal areas are now at or over T-200, which means that last week's Met Office forecast was spot on.

Additional squares forecast to reach T-200 by this weekend are 6, 8, 22, 24, 28, 33, 37, 40, 49, 55, 56, 60, 61, 64, 65, 76, 77, 82, 84, 85, 91, 95, and 98.

This means that 85% of Britain will be at or above T-200 by the weekend. The pattern is very similar to last year and some four weeks later than average, but 1979 was the latest season on record since the UKF T-sum service began in 1978.

In general, ground conditions for fertiliser spreading are still not good and farmers must exploit opportunities as they occur from now on.

Last week's advice on spreading still applies.

FIGURE 2

50 KM T-SUM SQUARES.

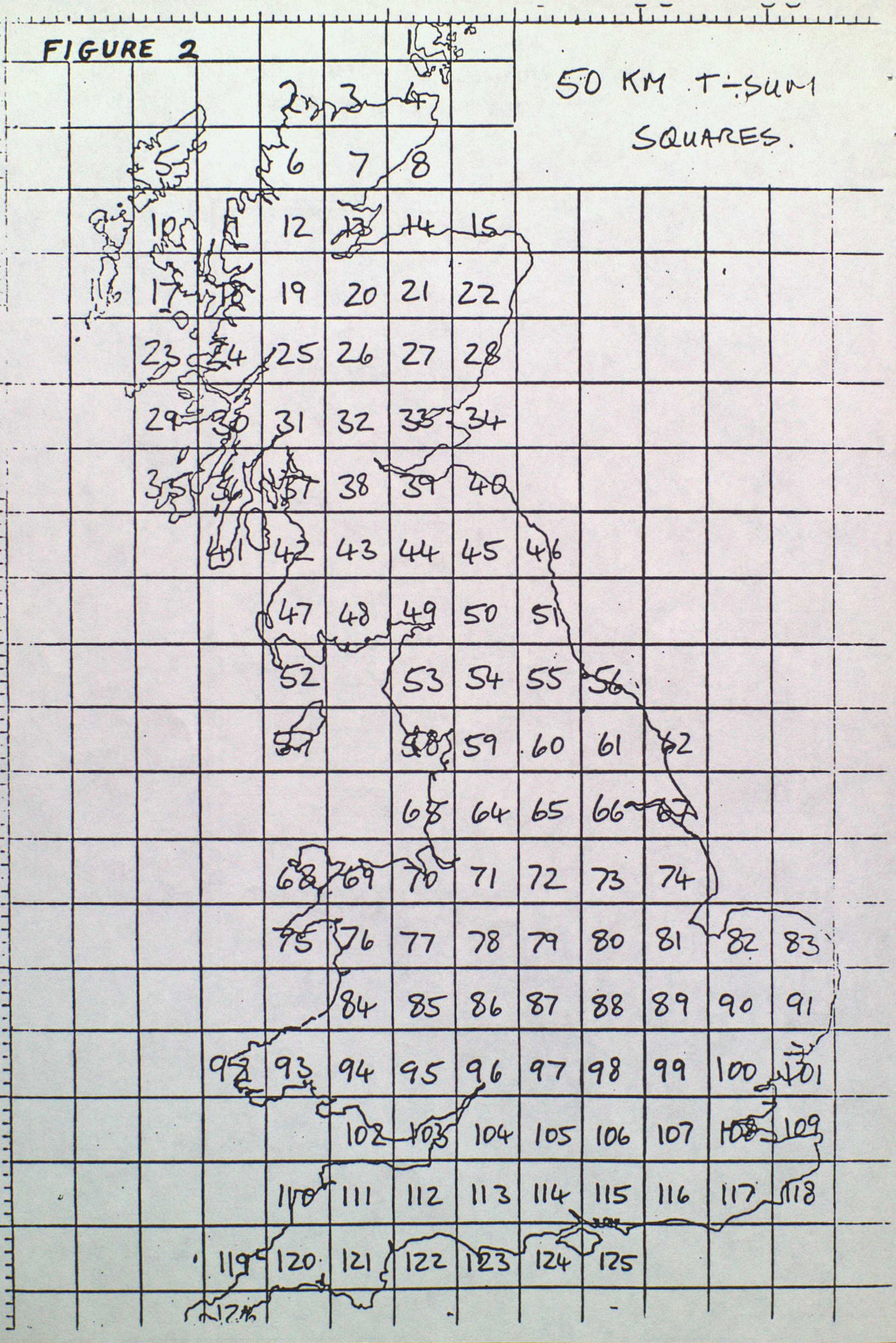
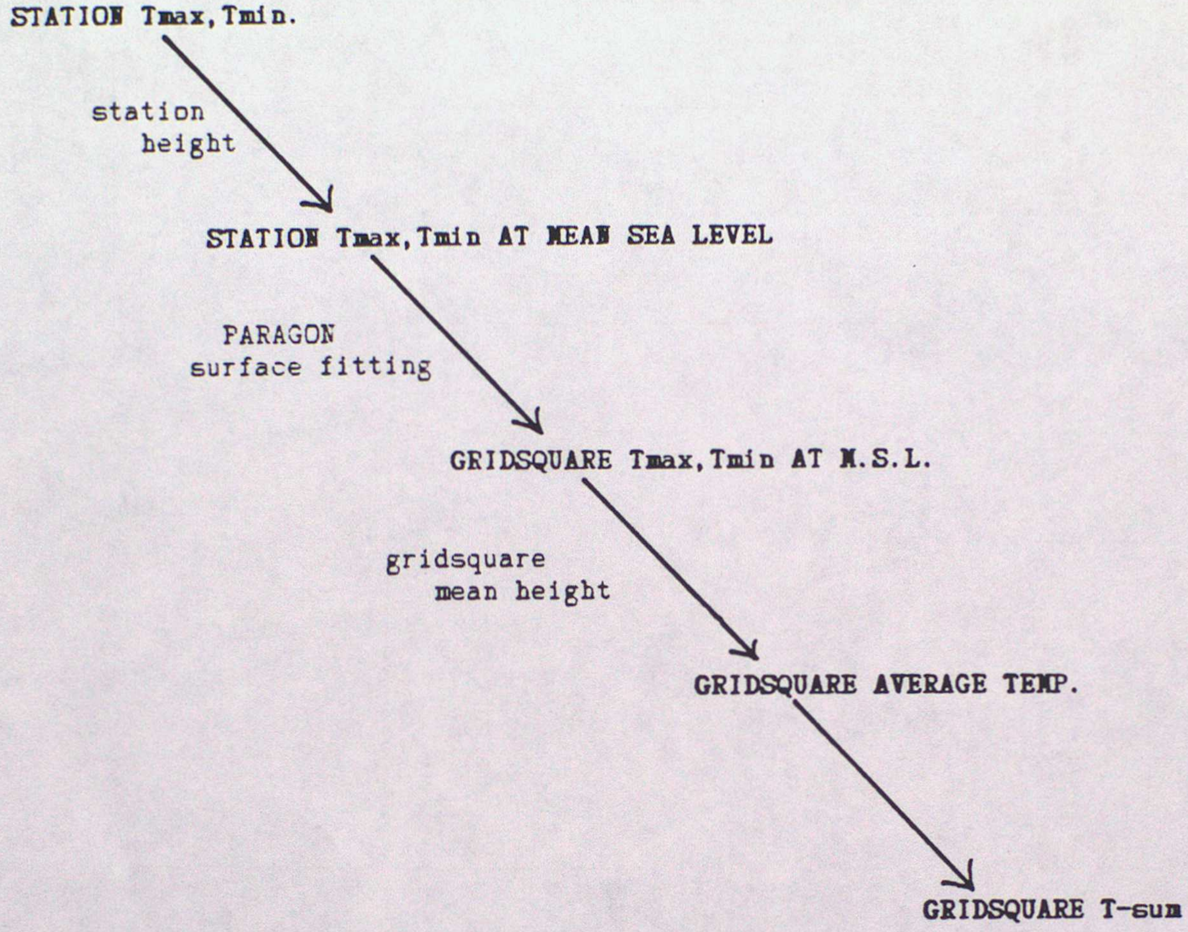
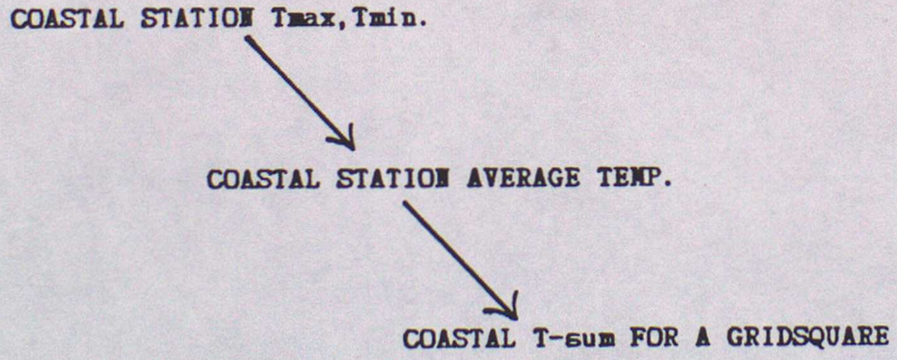

1
2 3 4
5 6 7 8
10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28
29 30 31 32 33 34
35 36 37 38 39 40
41 42 43 44 45 46
47 48 49 50 51
52 53 54 55 56
57 58 59 60 61 62
63 64 65 66 67
68 69 70 71 72 73 74
75 76 77 78 79 80 81 82 83
84 85 86 87 88 89 90 91
92 93 94 95 96 97 98 99 100 101
102 103 104 105 106 107 108 109
110 111 112 113 114 115 116 117 118
119 120 121 122 123 124 125
126

FIGURE 3 PROCEDURE USED TO CALCULATE T-SUMS.


STATION Tmax,Tmin.
station height
STATION Tmax,Tmin AT MEAN SEA LEVEL
PARAGON surface fitting
GRIDSQUARE Tmax,Tmin AT M.S.L.
gridsquare mean height
GRIDSQUARE AVERAGE TEMP.
GRIDSQUARE T-sum

COASTAL T-sums

If there is a coastal station in the gridsquare:


COASTAL STATION Tmax,Tmin.
COASTAL STATION AVERAGE TEMP.
COASTAL T-sum FOR A GRIDSQUARE

If there is no coastal station in the gridsquare:

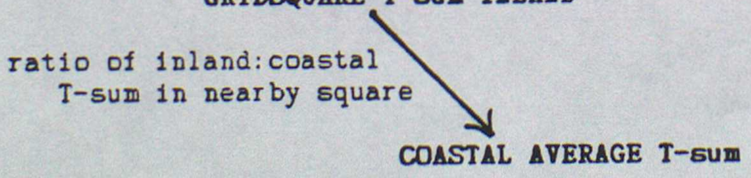
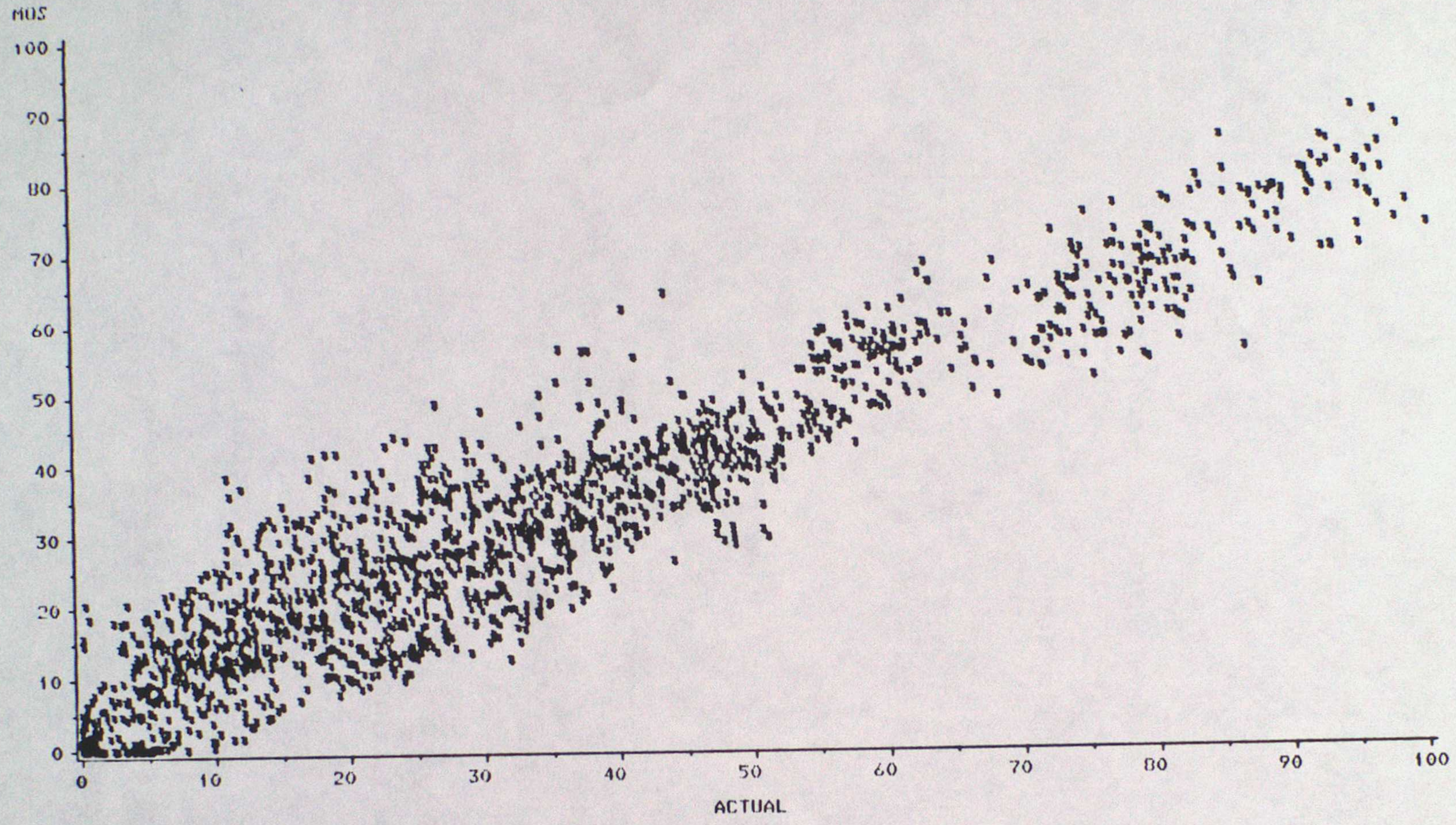

GRIDSQUARE T-sum INLAND
ratio of inland:coastal T-sum in nearby square
COASTAL AVERAGE T-sum

Fig. 4 (a)

WEEKLY TSUM(MOS) V TSUM(ACTUAL)

(1 JAN - 30 APR 1987)



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WEEKLY TSUM(PRINTFILE) V TSUM(ACTUAL)

(1 JAN - 30 APR 1987)

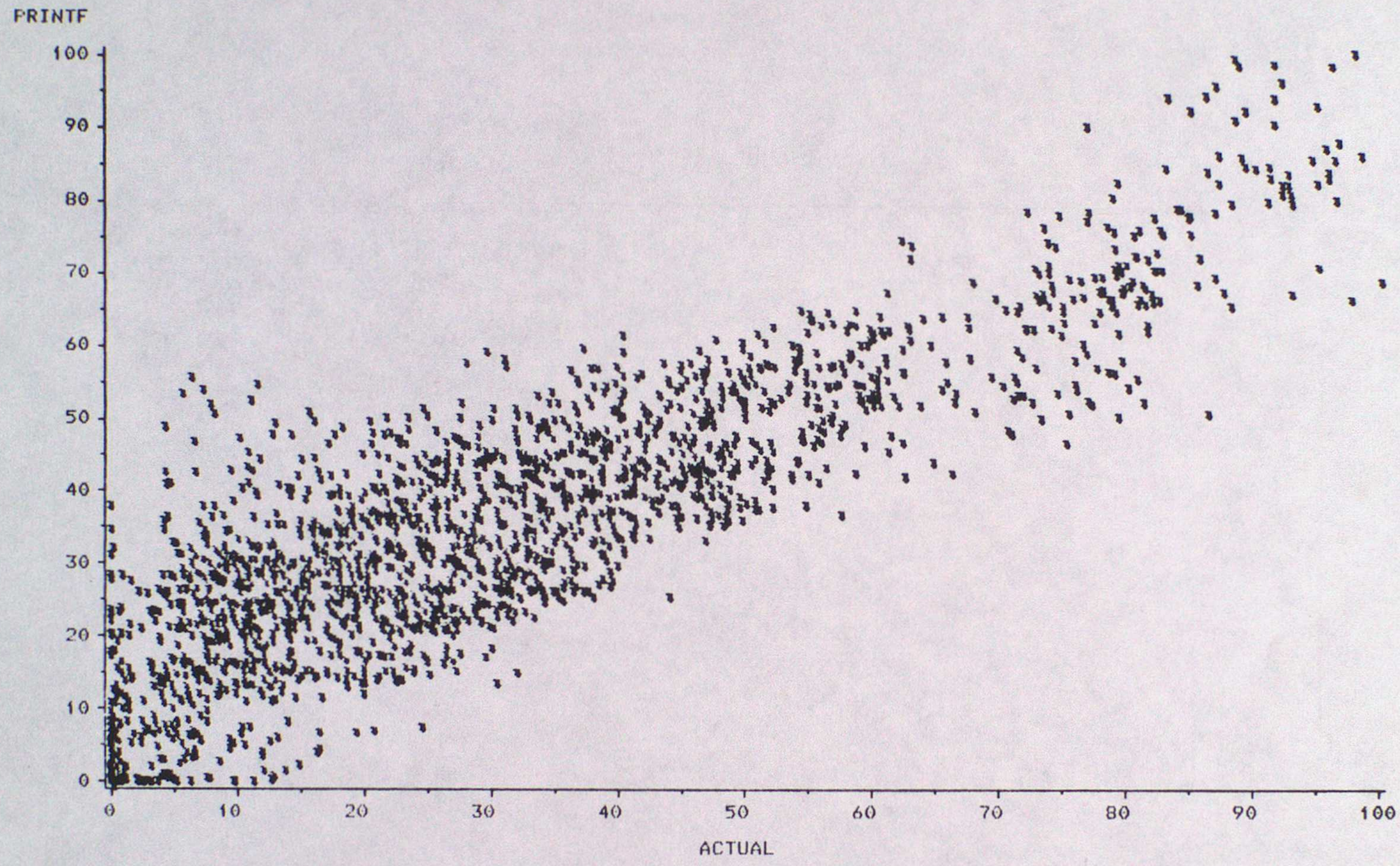

Fig 4 (b)

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Fig 4 (c)

WEEKLY TSUM(PERSIST) V TSUM(ACTUAL)

(1 JAN - 30 APR 1987)

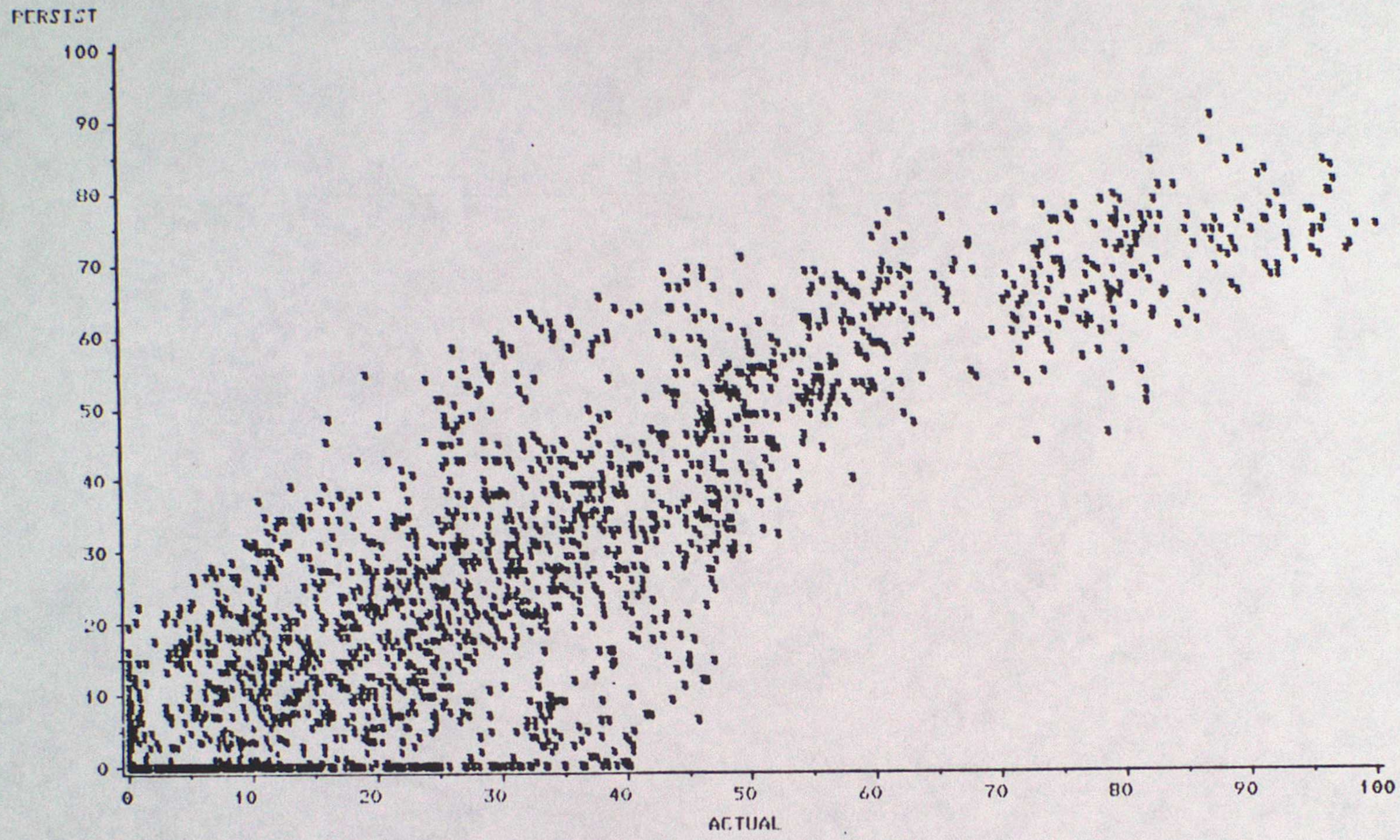

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Fig 4(d)

WEEKLY TSUM(CLIMATE) V TSUM(ACTUAL)

(1 JAN – 30 APR 1987)

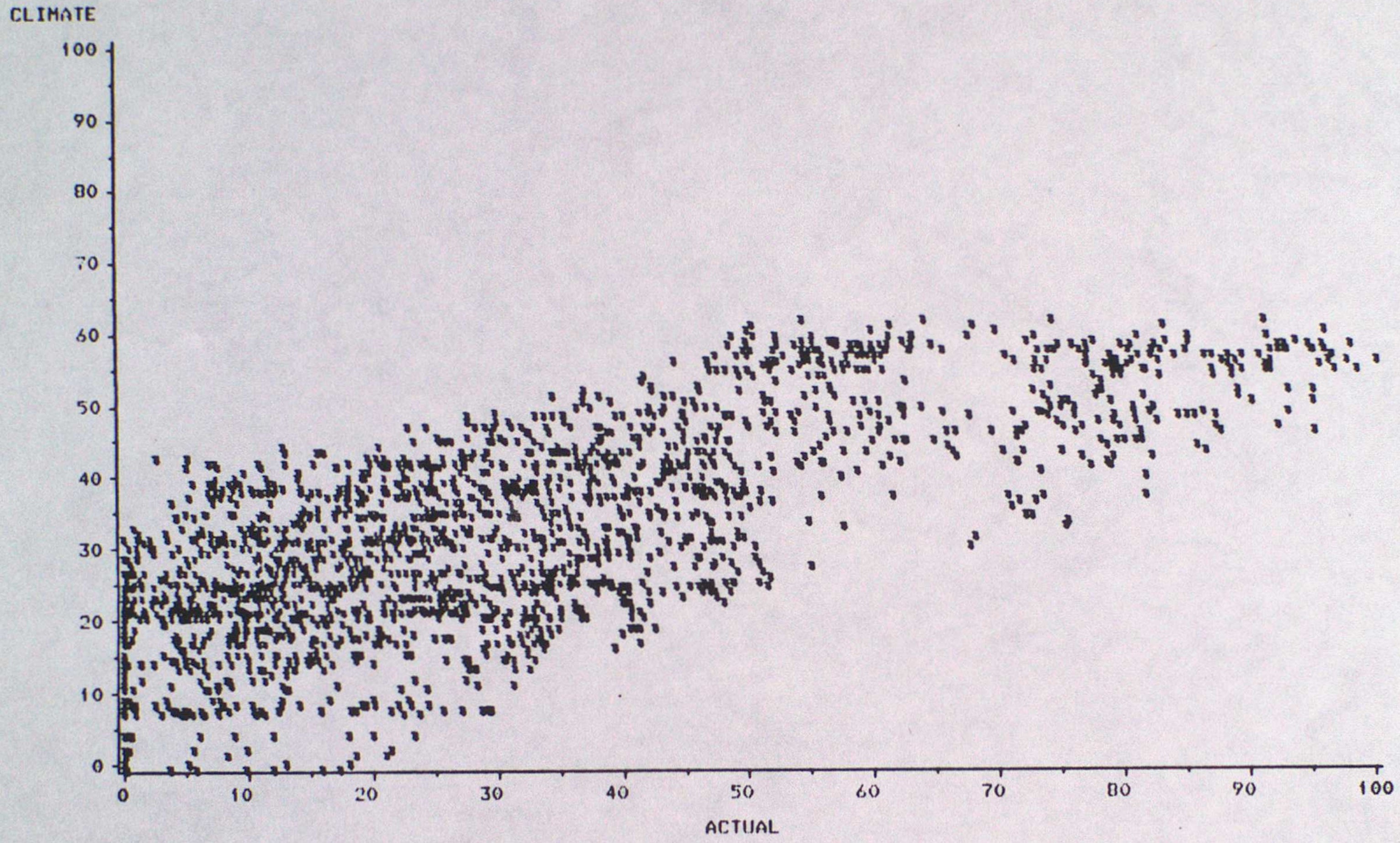

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FIG 5(a)

WEEKLY TSUM–MOS FORECAST AND ACTUAL SQUARE 112

(1 JAN – 30 APR 1987)

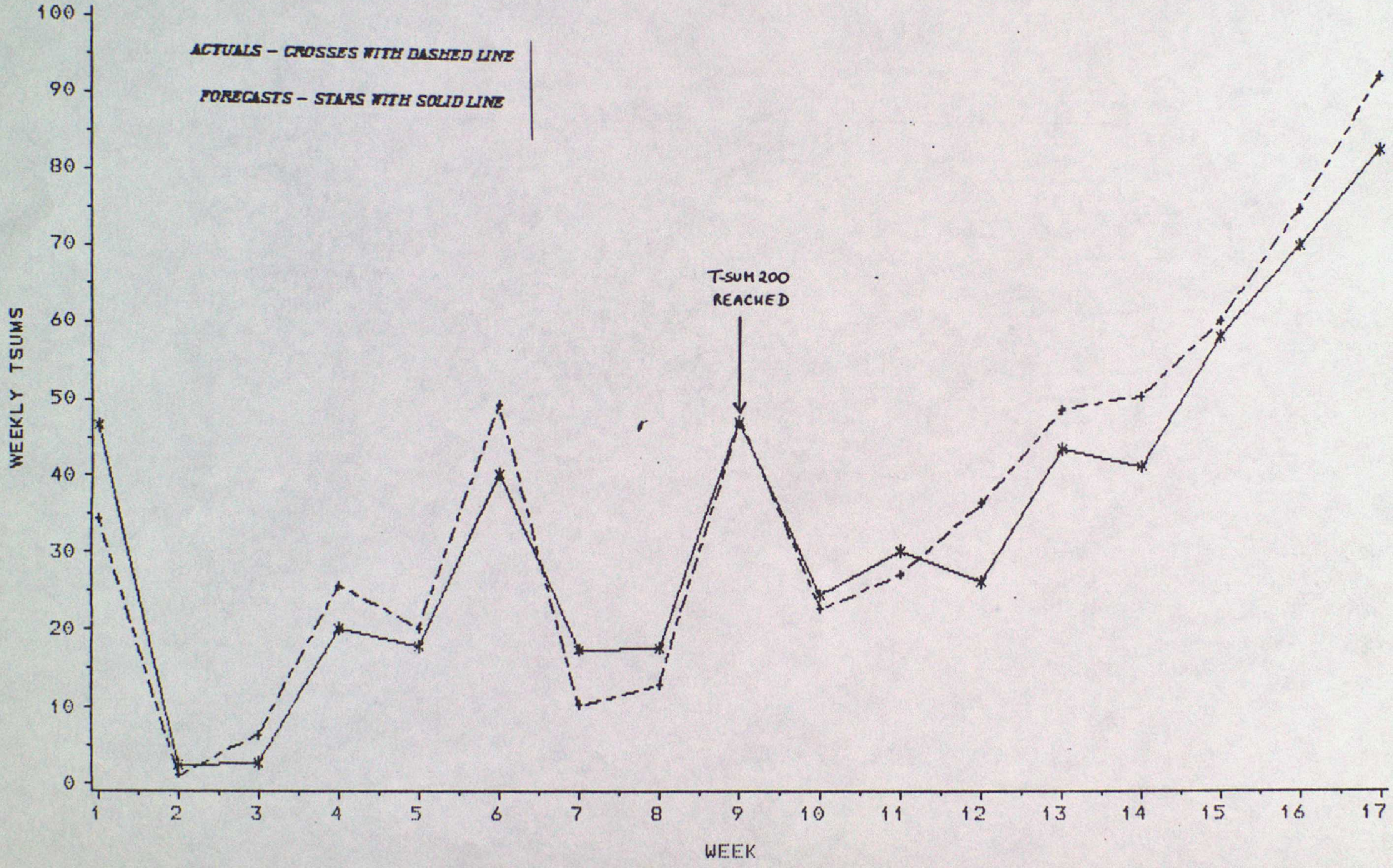


FIG 5(b)

WEEKLY TSUM-MOS AND ACTUAL SQUARE 25

(1 JAN - 30 APR 1987)

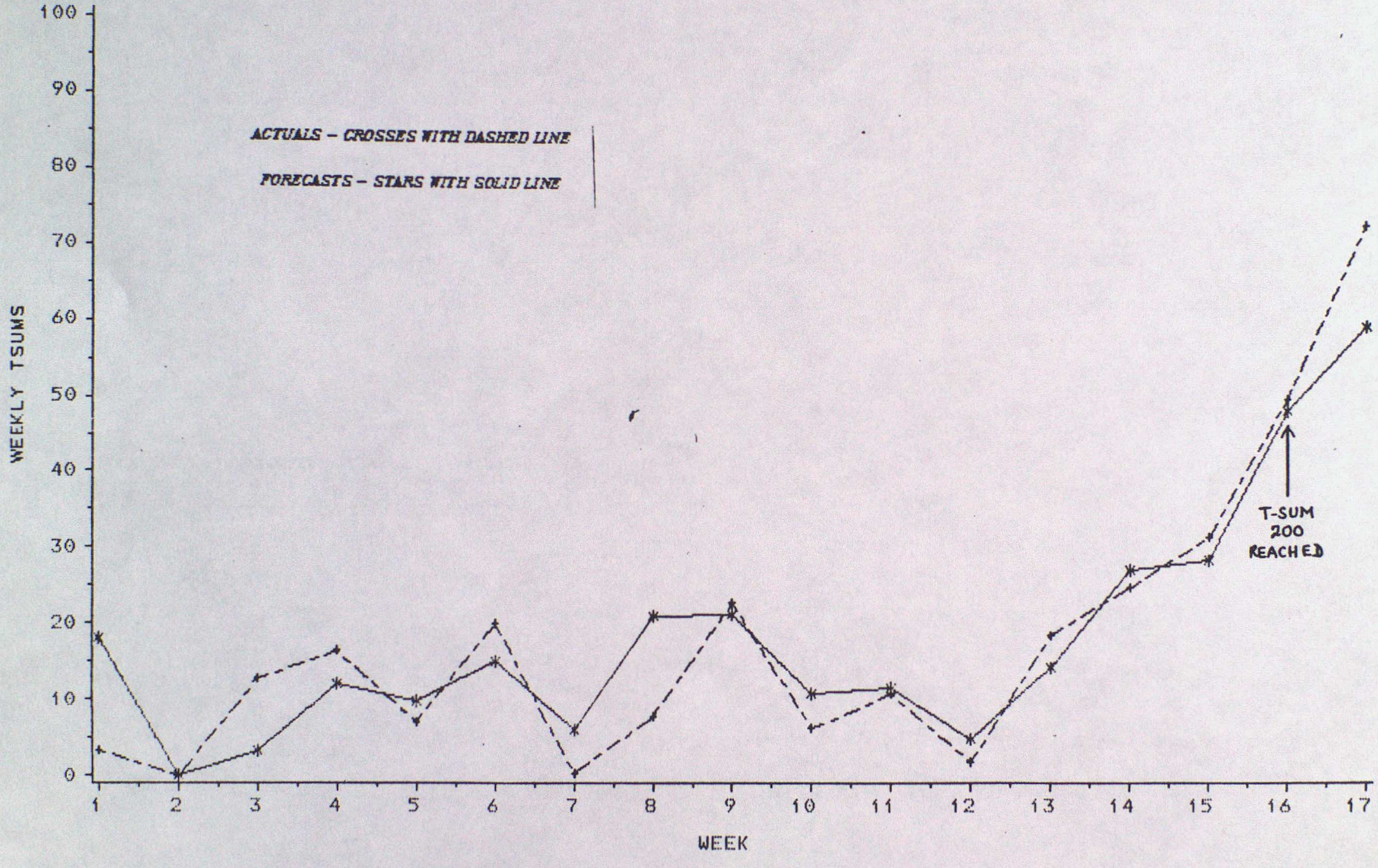


FIG 5(c)

WEEKLY TSUM-MOS FORECAST AND ACTUAL SQUARE 66

(1 JAN - 30 APR 1987)

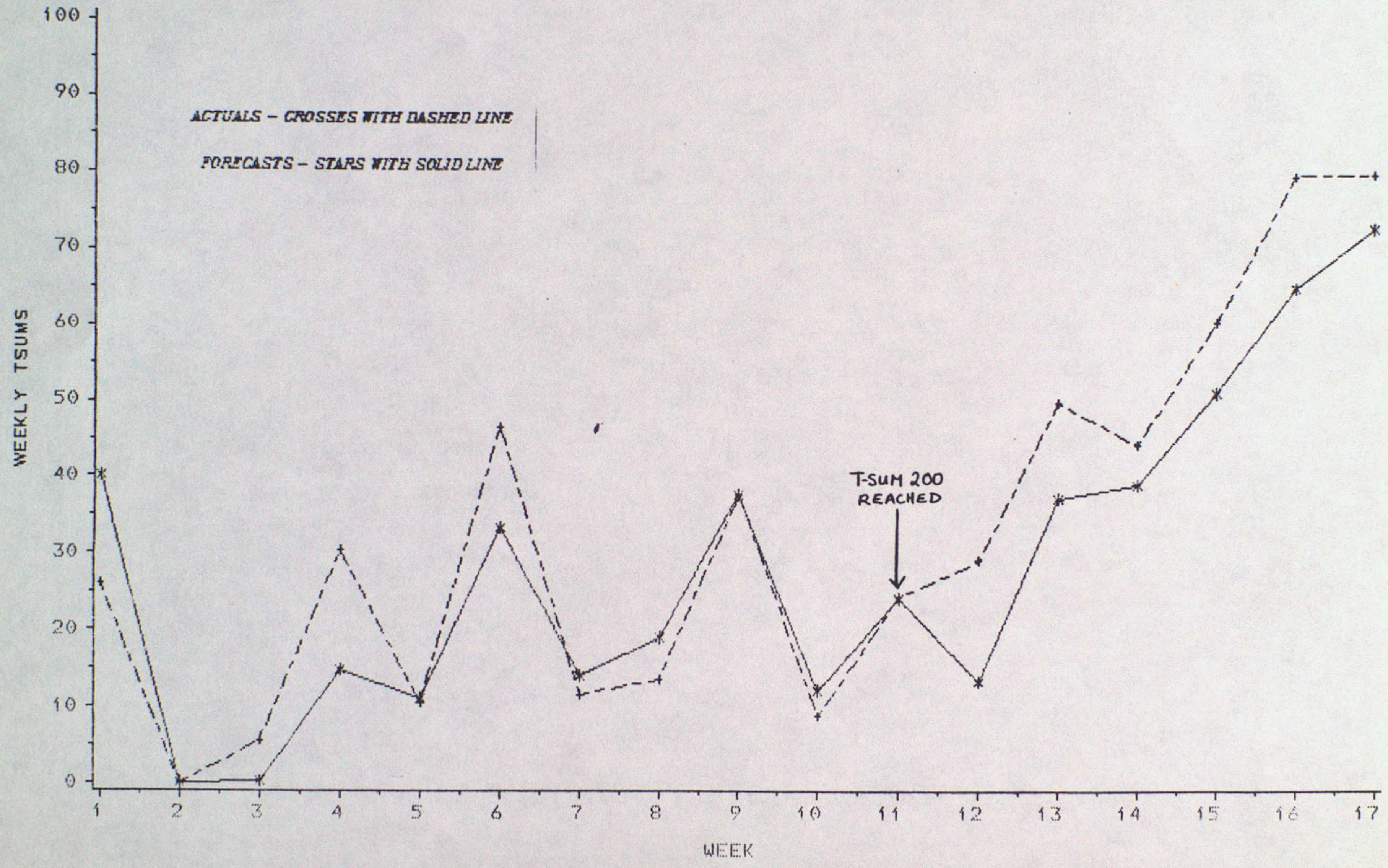
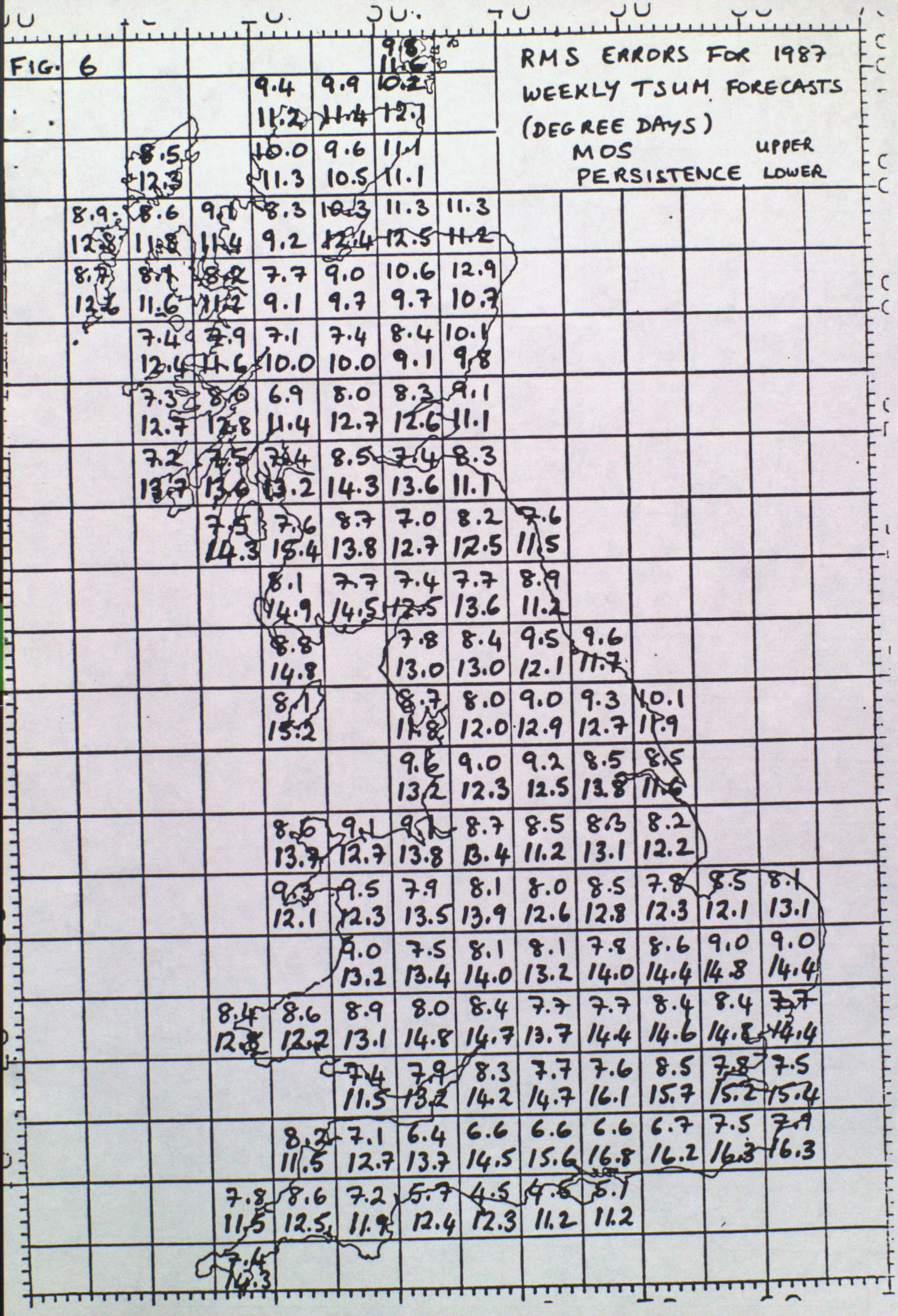


FIG. 6



RMS ERRORS FOR 1987 WEEKLY TSUM FORECASTS (DEGREE DAYS)

MOS	UPPER
PERSISTENCE	LOWER

					9.8 11.6						
			9.4 11.2	9.9 11.4	10.2 12.1						
	8.5 12.3		10.0 11.3	9.6 10.5	11.1 11.1						
8.9 12.8	8.6 11.8	9.1 11.4	8.3 9.2	10.3 12.4	11.3 12.5	11.3 11.2					
8.7 12.6	8.7 11.6	8.2 11.2	7.7 9.1	9.0 9.7	10.6 9.7	12.9 10.7					
	7.4 12.4	7.9 11.6	7.1 10.0	7.4 10.0	8.4 9.1	10.1 9.8					
	7.3 12.7	8.0 12.8	6.9 11.4	8.0 12.7	8.3 12.6	9.1 11.1					
	7.2 13.7	7.5 13.6	7.4 13.2	8.5 14.3	7.4 13.6	8.3 11.1					
		7.5 14.3	7.6 15.4	8.7 13.8	7.0 12.7	8.2 12.5	7.6 11.5				
			8.1 14.9	7.7 14.5	7.4 12.5	7.7 13.6	8.9 11.2				
			8.8 14.8		7.8 13.0	8.4 13.0	9.5 12.1	9.6 11.7			
			8.1 15.2		8.7 11.8	8.0 12.0	9.0 12.9	9.3 12.7	10.1 11.9		
					9.6 13.2	9.0 12.3	9.2 12.5	8.5 13.8	8.5 11.6		
			8.6 13.7	9.1 12.7	9.1 13.8	8.7 13.4	8.5 11.2	8.3 13.1	8.2 12.2		
			9.3 12.1	9.5 12.3	7.9 13.5	8.1 13.9	8.0 12.6	8.5 12.8	7.8 12.3	8.5 12.1	8.1 13.1
				9.0 13.2	7.5 13.4	8.1 14.0	8.1 13.2	7.8 14.0	8.6 14.4	9.0 14.8	9.0 14.4
		8.4 12.8	8.6 12.2	8.9 13.1	8.0 14.8	8.4 14.7	7.7 13.7	7.7 14.4	8.4 14.6	8.4 14.8	7.7 14.4
				7.4 11.5	7.9 13.2	8.3 14.2	7.7 14.7	7.6 16.1	8.5 15.7	7.8 15.2	7.5 15.4
			8.2 11.5	7.1 12.7	6.4 13.7	6.6 14.5	6.6 15.6	6.6 16.8	6.7 16.2	7.5 16.3	7.9 16.3
		7.8 11.5	8.6 12.5	7.2 11.9	5.7 12.4	4.5 12.3	4.5 11.2	5.1 11.2			
		7.4 14.3									

FIG 7(a)

ERROR IN MOS 1987

T-SUM 200 (DAYS)

– MOS LATE

+ MOS EARLY

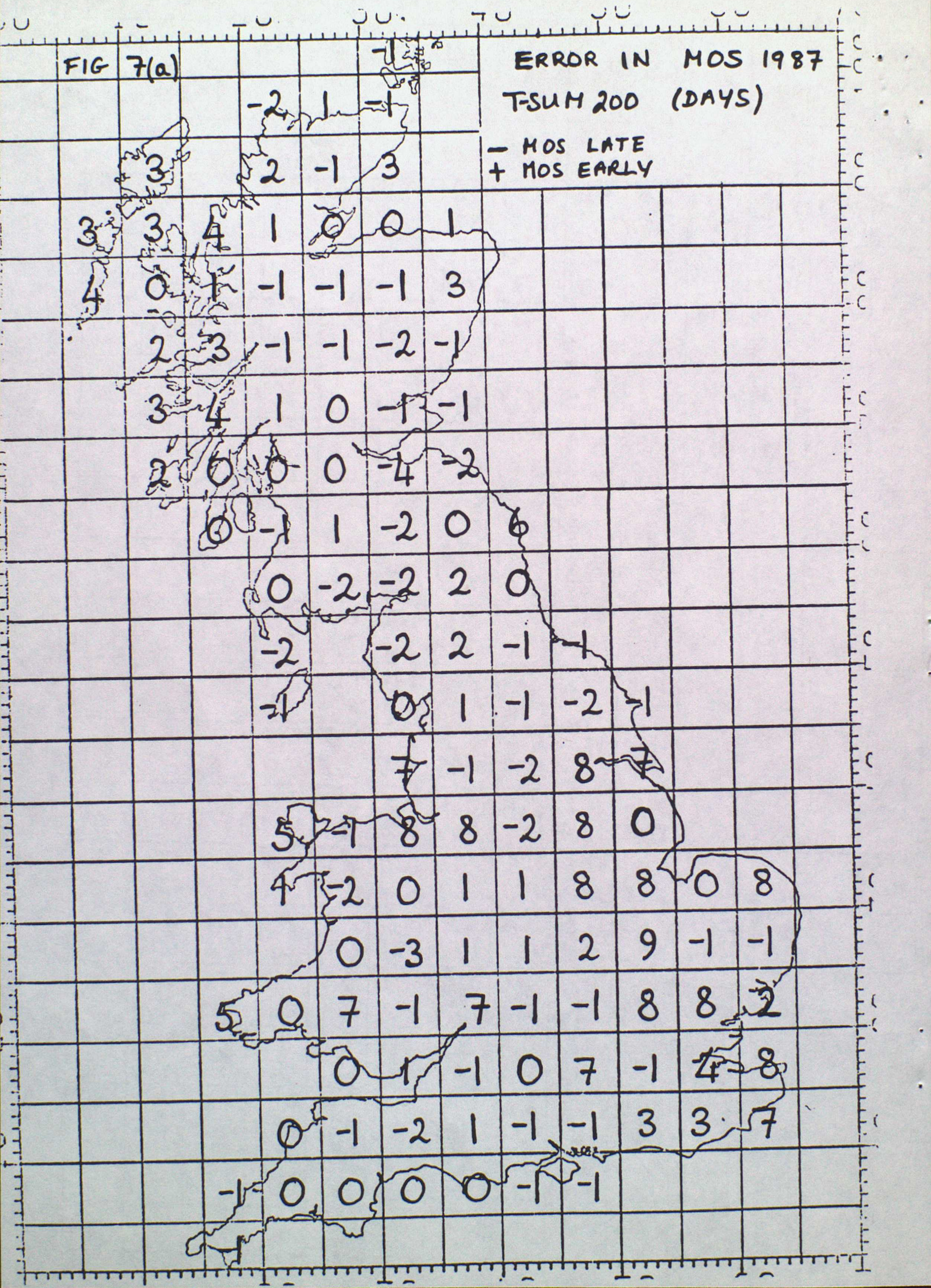

-1
-2 1 -1
3 2 -1 3
3 3 4 1 0 0 1
4 0 1 -1 -1 -1 3
2 3 -1 -1 -2 -1
3 4 1 0 -1 -1
2 0 0 0 -4 -2
0 -1 1 -2 0 6
0 -2 -2 2 0
-2 -2 2 -1 -1
-1 0 1 -1 -2 -1
7 -1 -2 8 7
5 -1 8 8 -2 8 0
4 -2 0 1 1 8 8 0 8
0 -3 1 1 2 9 -1 -1
5 0 7 -1 7 -1 -1 8 8 2
0 1 -1 0 7 -1 4 8
0 -1 -2 1 -1 -1 3 3 7
-1 0 0 0 0 -1 -1

FIG 7(b)

ERROR IN PRINTFILE (T*)

T-SUM 200 (DAYS)

+ => PRINTFILE EARLY

- => PRINTFILE LATE

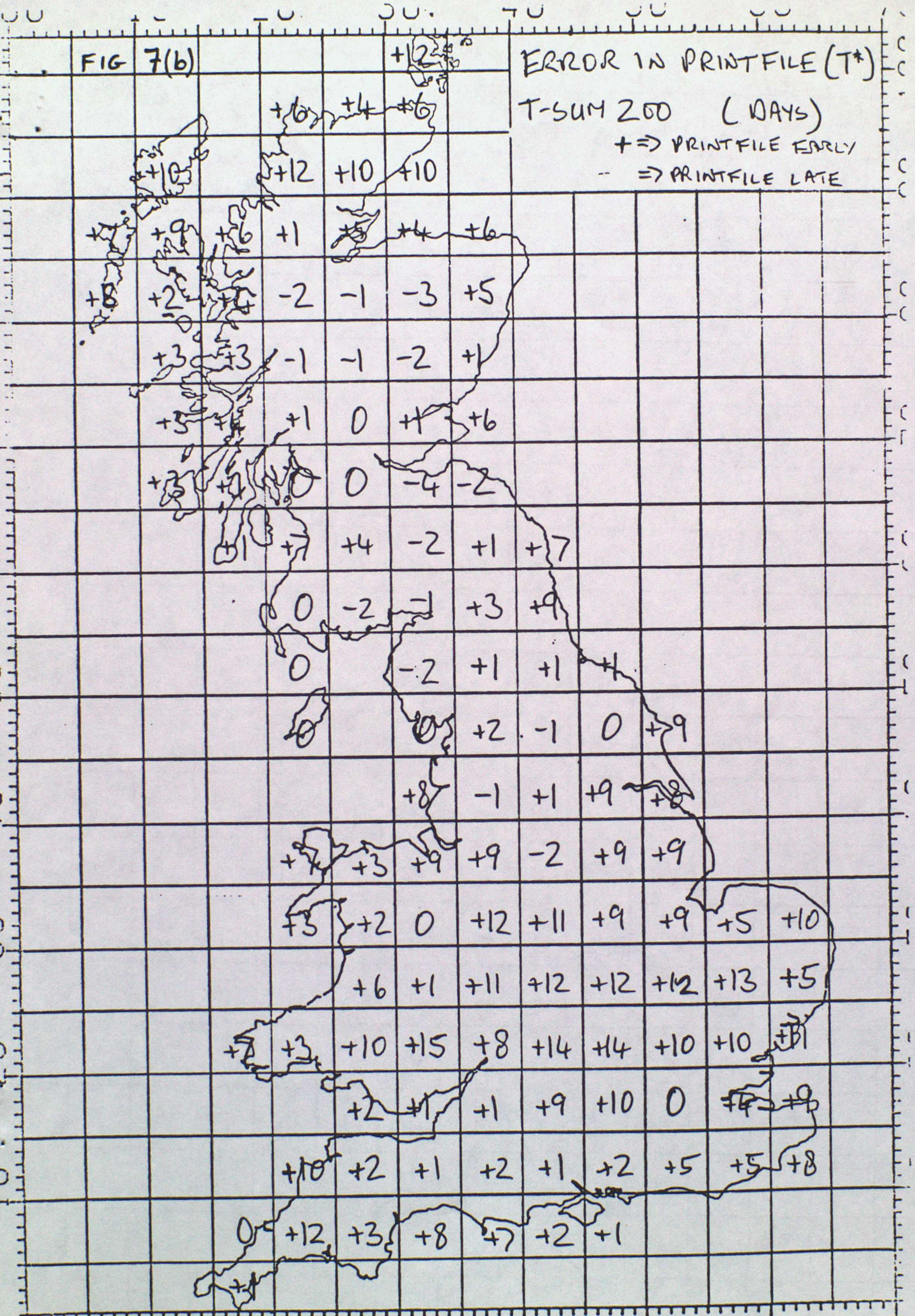

+12
+6 +4 +6
+10 +12 +10 +10
+7 +9 +6 +1 +5 +4 +6
+8 +2 +6 -2 -1 -3 +5
+3 +3 -1 -1 -2 +1
+5 +4 +1 0 +1 +6
+3 +4 0 0 -4 -2
+1 +7 +4 -2 +1 +7
0 -2 -1 +3 +9
0 -2 +1 +1 +1
0 0 +2 -1 0 +9
+8 -1 +1 +9 +8
+4 +3 +9 +9 -2 +9 +9
+3 +2 0 +12 +11 +9 +9 +5 +10
+6 +1 +11 +12 +12 +12 +13 +5
+5 +3 +10 +15 +8 +14 +14 +10 +10 +11
+2 +1 +1 +9 +10 0 +4 +9
+10 +2 +1 +2 +1 +2 +5 +5 +8
0 +12 +3 +8 +7 +2 +1
+4

FIG 7(c)

ERROR IN PERSISTENCE
T-SUM 200 (DAYS)
- => PERSISTENCE LATE
+ => PERSISTENCE EARLY

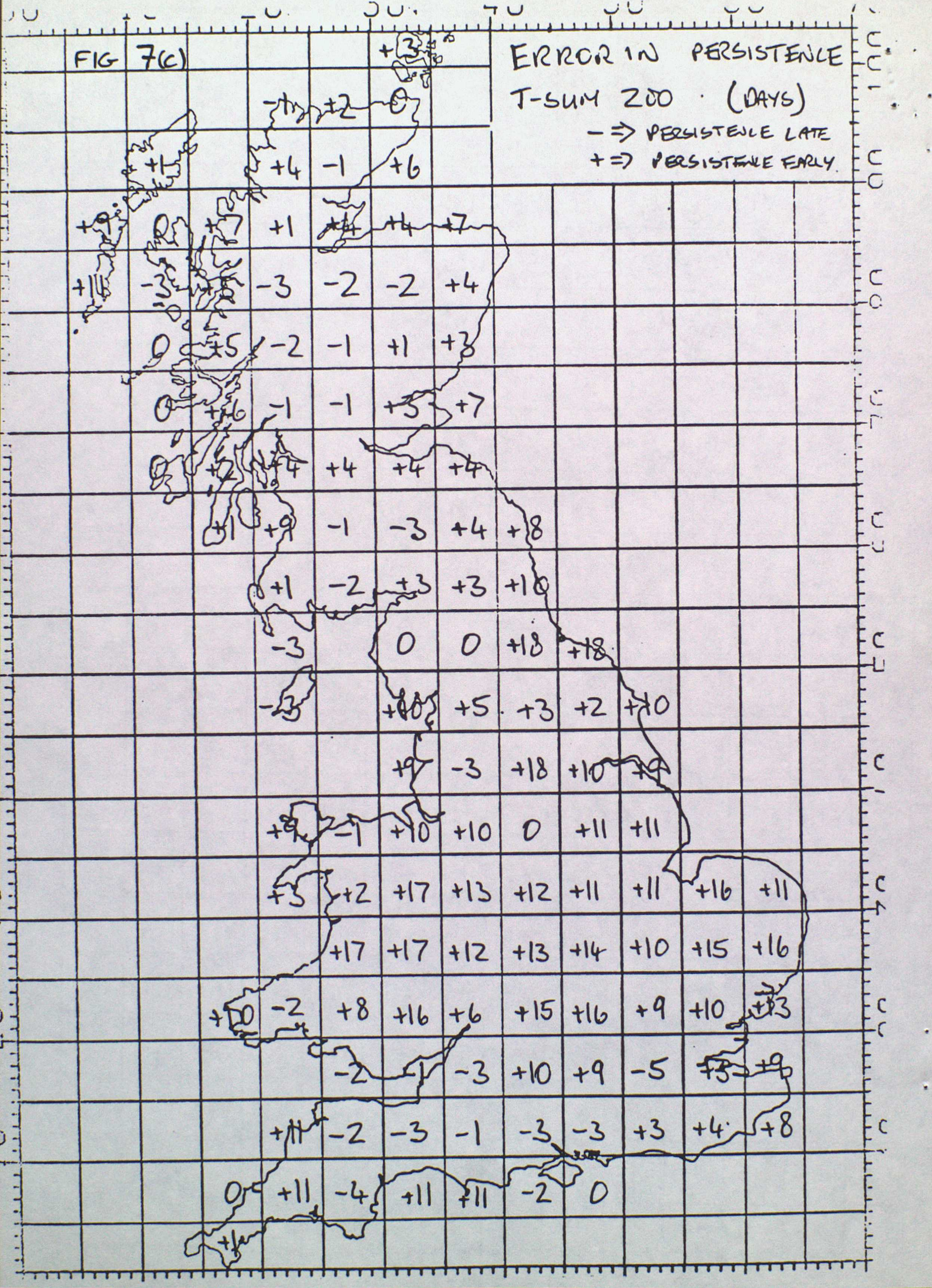

+3
-1 +2 0
+1 +4 -1 +6
+9 0 +7 +1 +4 +4 +7
+14 -3 +5 -3 -2 -2 +4
0 +5 -2 -1 +1 +3
0 +6 -1 -1 +5 +7
0 +2 +4 +4 +4 +4
+1 +9 -1 -3 +4 +8
+1 -2 +3 +3 +10
-3 0 0 +18 +18
-3 +10 +5 +3 +2 +10
+9 -3 +18 +10 +9
+9 -1 +10 +10 0 +11 +11
+3 +2 +17 +13 +12 +11 +11 +16 +11
+17 +17 +12 +13 +14 +10 +15 +16
+10 -2 +8 +16 +6 +15 +16 +9 +10 +13
-2 -1 -3 +10 +9 -5 +3 +9
+11 -2 -3 -1 -3 -3 +3 +4 +8
0 +11 -4 +11 +11 -2 0
+1

FIG 7(d)

ERROR IN CLIMATOLOGY

T SUM 200 (DAILY)

− ⇒ CLIMATOLOGY LATE

+ ⇒ CLIMATOLOGY EARLY

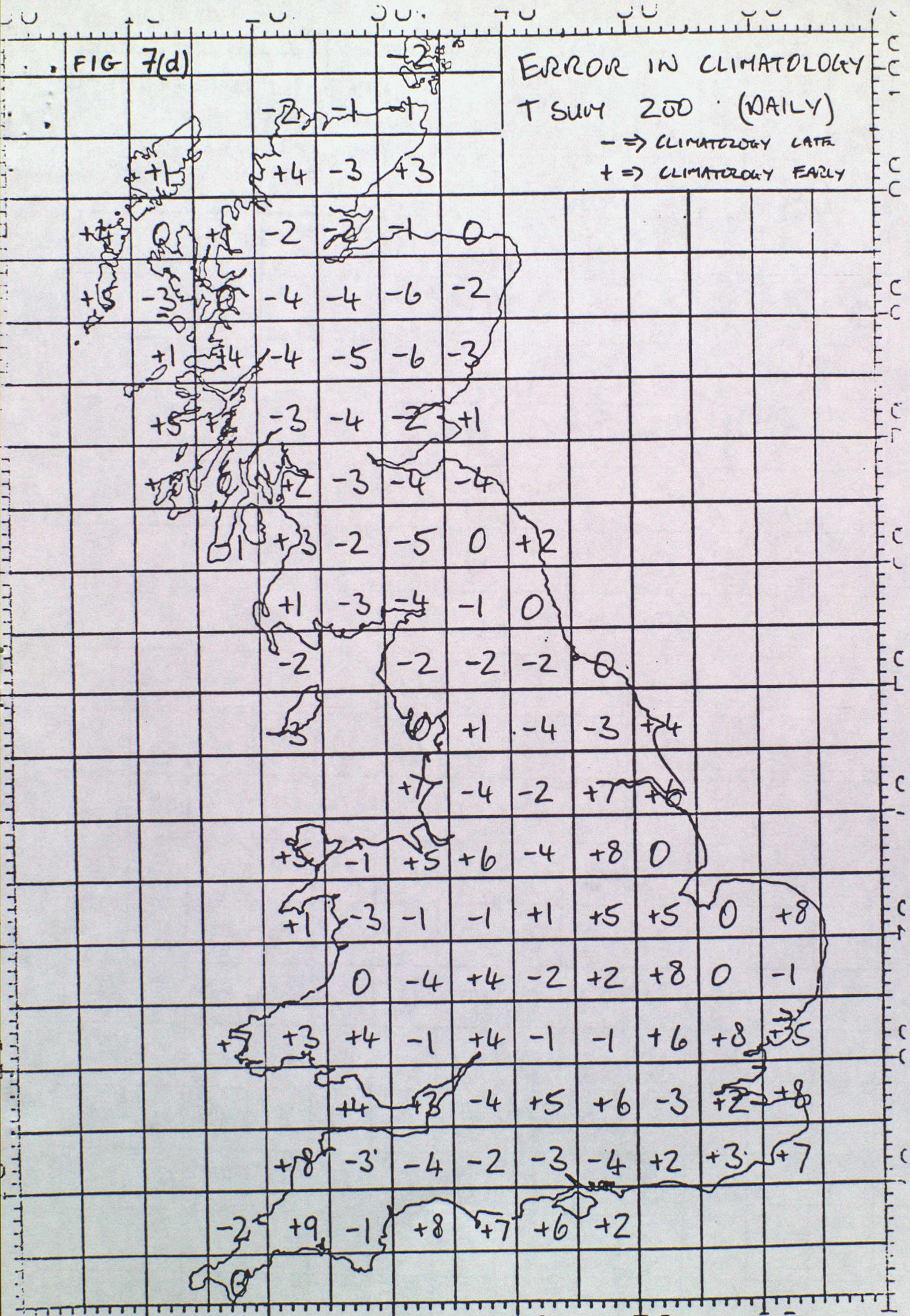

-2
-2 -1 -1
+1 +4 -3 +3
+4 0 +1 -2 -2 -1 0
+5 -3 0 -4 -4 -6 -2
+1 +4 -4 -5 -6 -3
+5 +2 -3 -4 -2 +1
0 +2 -3 -4 -4
-1 +3 -2 -5 0 +2
+1 -3 -4 -1 0
-2 -2 -2 -2 0
-3 0 +1 -4 -3 +4
+7 -4 -2 +7 +6
+5 -1 +5 +6 -4 +8 0
+1 -3 -1 -1 +1 +5 +5 0 +8
0 -4 +4 -2 +2 +8 0 -1
+5 +3 +4 -1 +4 -1 -1 +6 +8 +5
+4 +3 -4 +5 +6 -3 +2 +8
+8 -3 -4 -2 -3 -4 +2 +3 +7
-2 +9 -1 +8 +7 +6 +2
0

FIG 8(a)

ERROR IN MOS T-SUM
200 (WEEKS) FOR
FARMERS WEEKLY
+ MOS EARLY
− MOS LATE

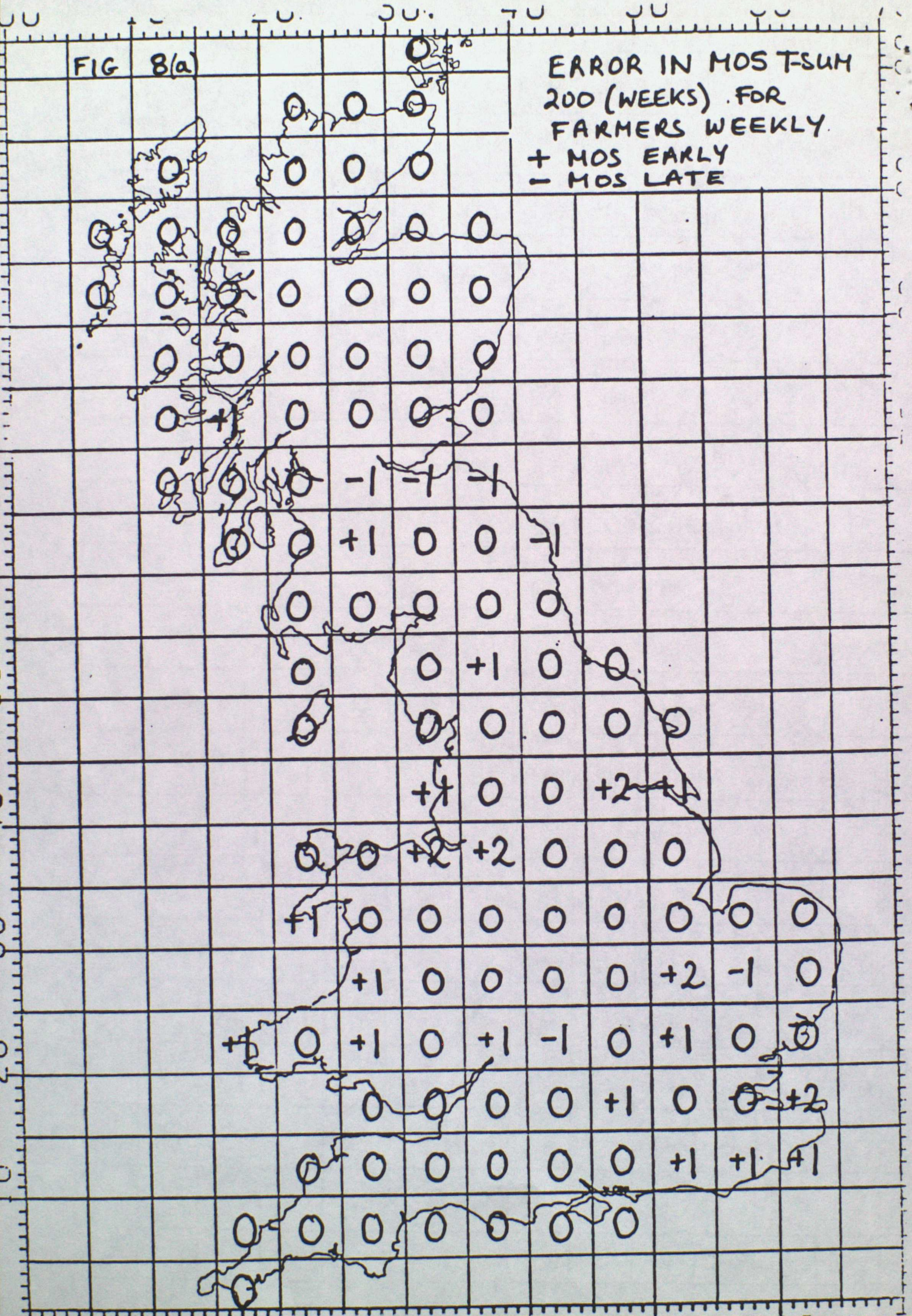
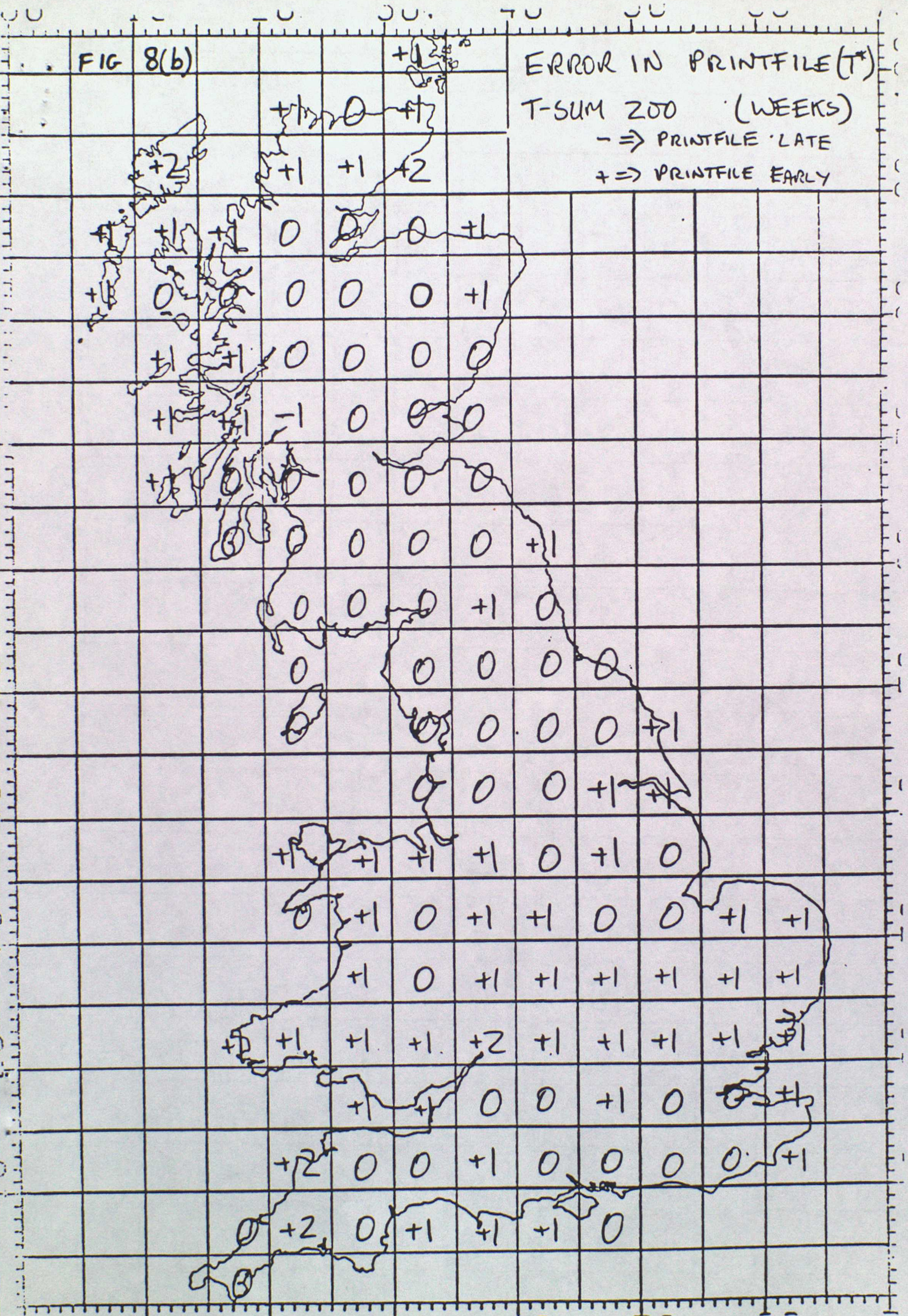

0
0 0 0
0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0
0 +1 0 0 0 0
0 0 0 -1 -1 -1
0 0 +1 0 0 -1
0 0 0 0 0
0 0 +1 0 0
0 0 0 0 0 0
+1 0 0 +2 +1
0 0 +2 +2 0 0 0
+1 0 0 0 0 0 0 0 0
+1 0 0 0 0 +2 -1 0
+1 0 +1 0 +1 -1 0 +1 0 0
0 0 0 0 +1 0 0 +2
0 0 0 0 0 0 +1 +1 +1
0 0 0 0 0 0 0

FIG 8(b)


+1
+1 0 +1
+2 +1 +1 +2
+1 +1 +1 0 0 0 +1
+1 0 0 0 0 0 +1
+1 +1 0 0 0 0
+1 +1 -1 0 0 0
+1 0 0 0 0 0
0 0 0 0 0 +1
0 0 0 +1 0
0 0 0 0 0
0 0 0 0 0 +1
0 0 0 +1 +1
+1 +1 +1 +1 0 +1 0
0 +1 0 +1 +1 0 0 +1 +1
+1 0 +1 +1 +1 +1 +1 +1
+1 +1 +1 +1 +2 +1 +1 +1 +1 +1
+1 +1 0 0 +1 0 0 +1
+2 0 0 +1 0 0 0 0 +1
0 +2 0 +1 +1 +1 0
0

ERROR IN PRINTFILE (T*)

T-SUM 200 (WEEKS)

- => PRINTFILE LATE

+ => PRINTFILE EARLY

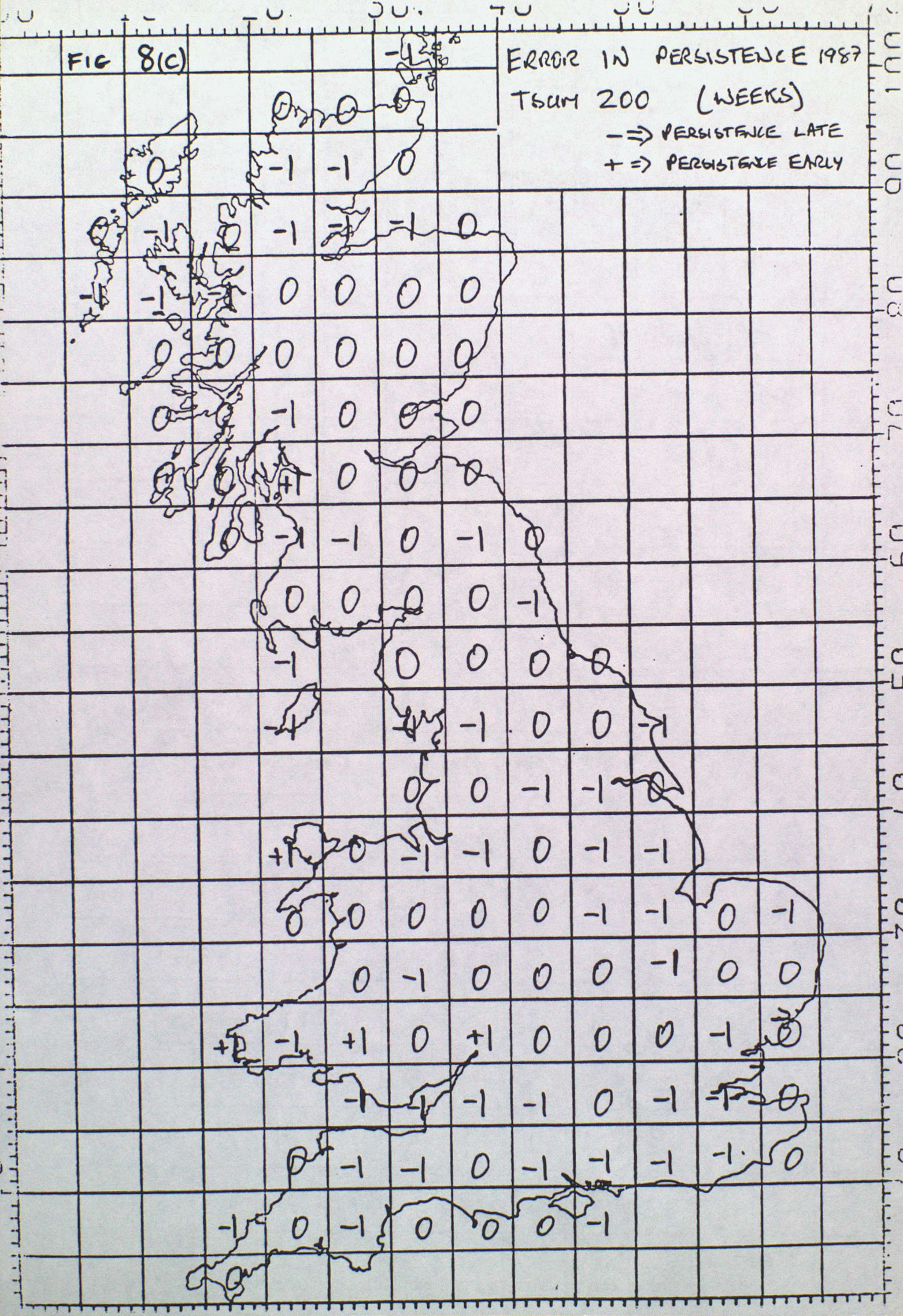
FIG 8(c)

ERROR IN PERSISTENCE 1987

TSUM 200 (WEEKS)

- ⇒ PERSISTENCE LATE

+ ⇒ PERSISTENCE EARLY


-1
0 0 0
0 -1 -1 0
0 -1 0 -1 -1 -1 0
-1 -1 0 0 0 0
0 0 0 0 0 0
0 0 -1 0 0 0
0 0 +1 0 0 0
0 -1 -1 0 -1 0
0 0 0 0 -1
-1 0 0 0 0
-1 -1 -1 0 0 -1
0 0 -1 -1 0
+1 0 -1 -1 0 -1 -1
0 0 0 0 0 -1 -1 0 -1
0 -1 0 0 0 -1 0 0
+1 -1 +1 0 +1 0 0 0 -1 0
-1 -1 -1 -1 0 -1 -1 0
0 -1 -1 0 -1 -1 -1 -1 0
-1 0 -1 0 0 0 -1

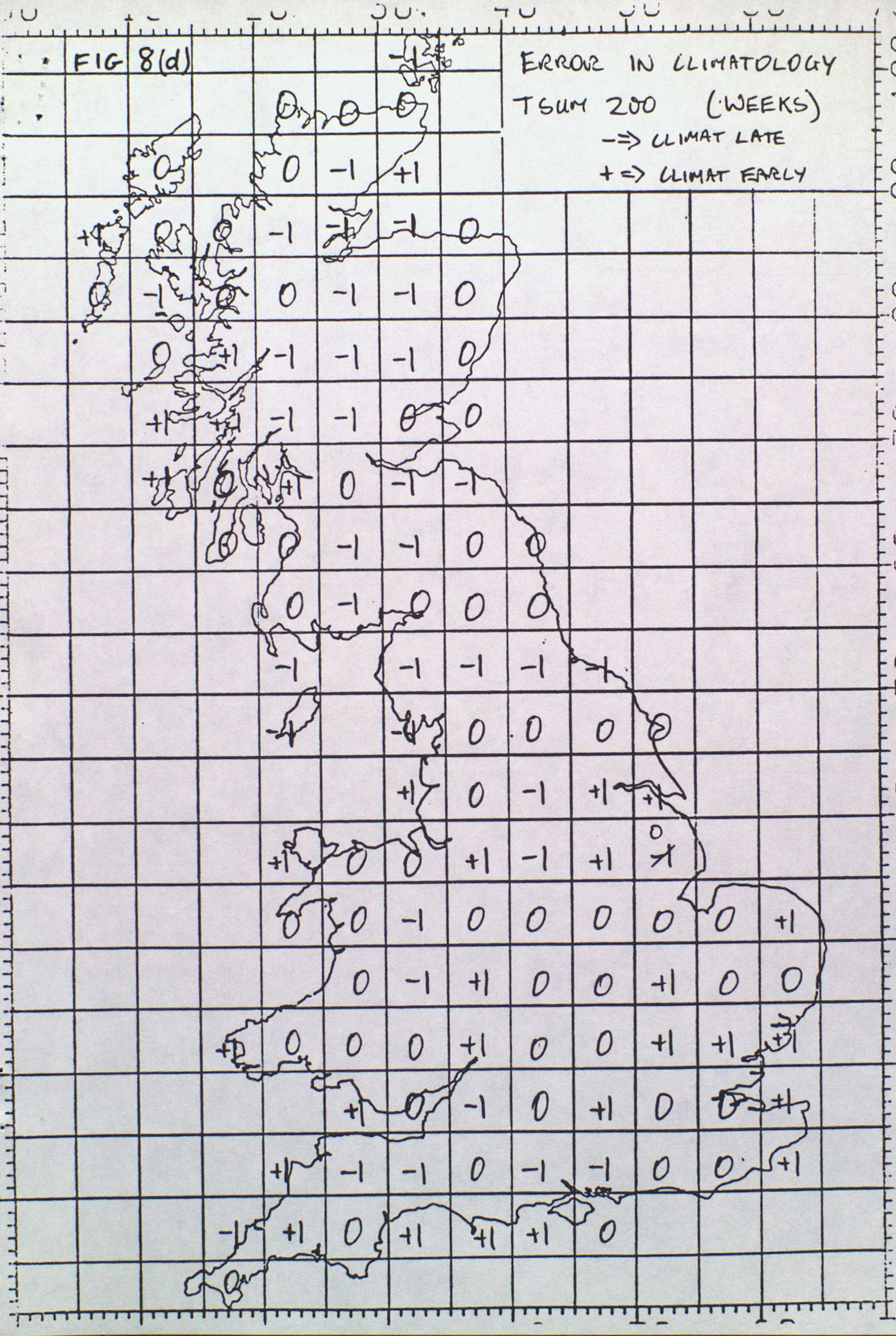


FIG 8(d)

ERROR IN CLIMATOLOGY
TSUM 200 (WEEKS)
- => CLIMAT LATE
+ => CLIMAT EARLY

-1
0 0 0
0 0 -1 +1
+1 0 0 -1 -1 -1 0
0 -1 0 0 -1 -1 0
0 +1 -1 -1 -1 0
+1 +1 -1 -1 0 0
+1 0 +1 0 -1 -1
0 0 -1 -1 0 0
0 -1 0 0 0
-1 -1 -1 -1 -1
-1 -1 0 0 0 0
+1 0 -1 +1 +1
0
+1 0 0 +1 -1 +1 +1
0 0 -1 0 0 0 0 0 +1
0 -1 +1 0 0 +1 0 0
+1 0 0 0 +1 0 0 +1 +1 +1
+1 0 -1 0 +1 0 0 +1
+1 -1 -1 0 -1 -1 0 0 +1
-1 +1 0 +1 +1 +1 0

FIG 9

FIG 9

DAILY TSUMS-MOS FORECAST AND ACTUAL SQUARE 89

(23 FEB - 16 MAR 1987)

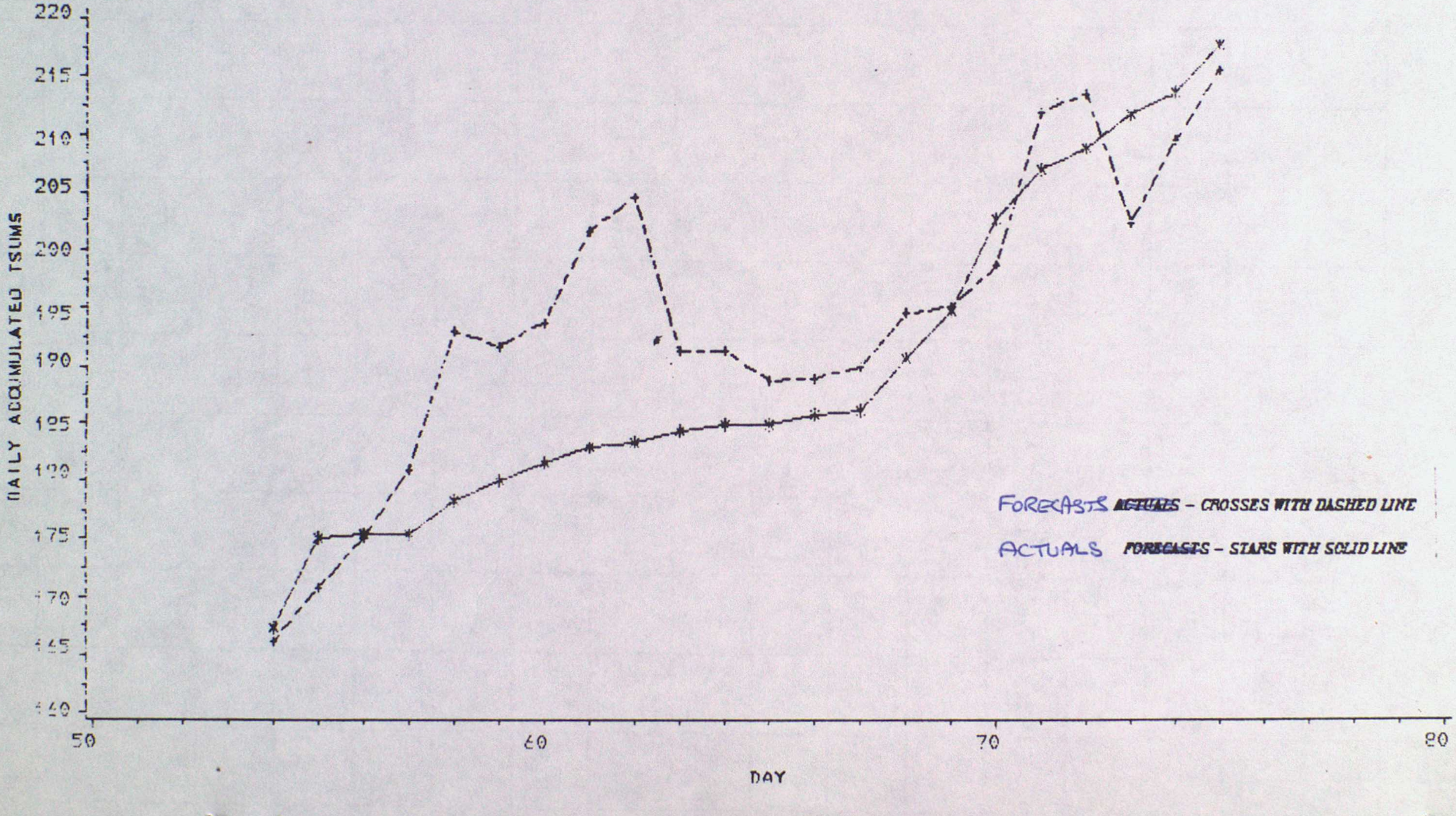


FIG 9 (AMENDED)

FIG 9 (AMENDED)

DAILY TSUMS-MOS FORECAST AND ACTUAL SQUARE 89

(23 FEB - 16 MAR 1987)

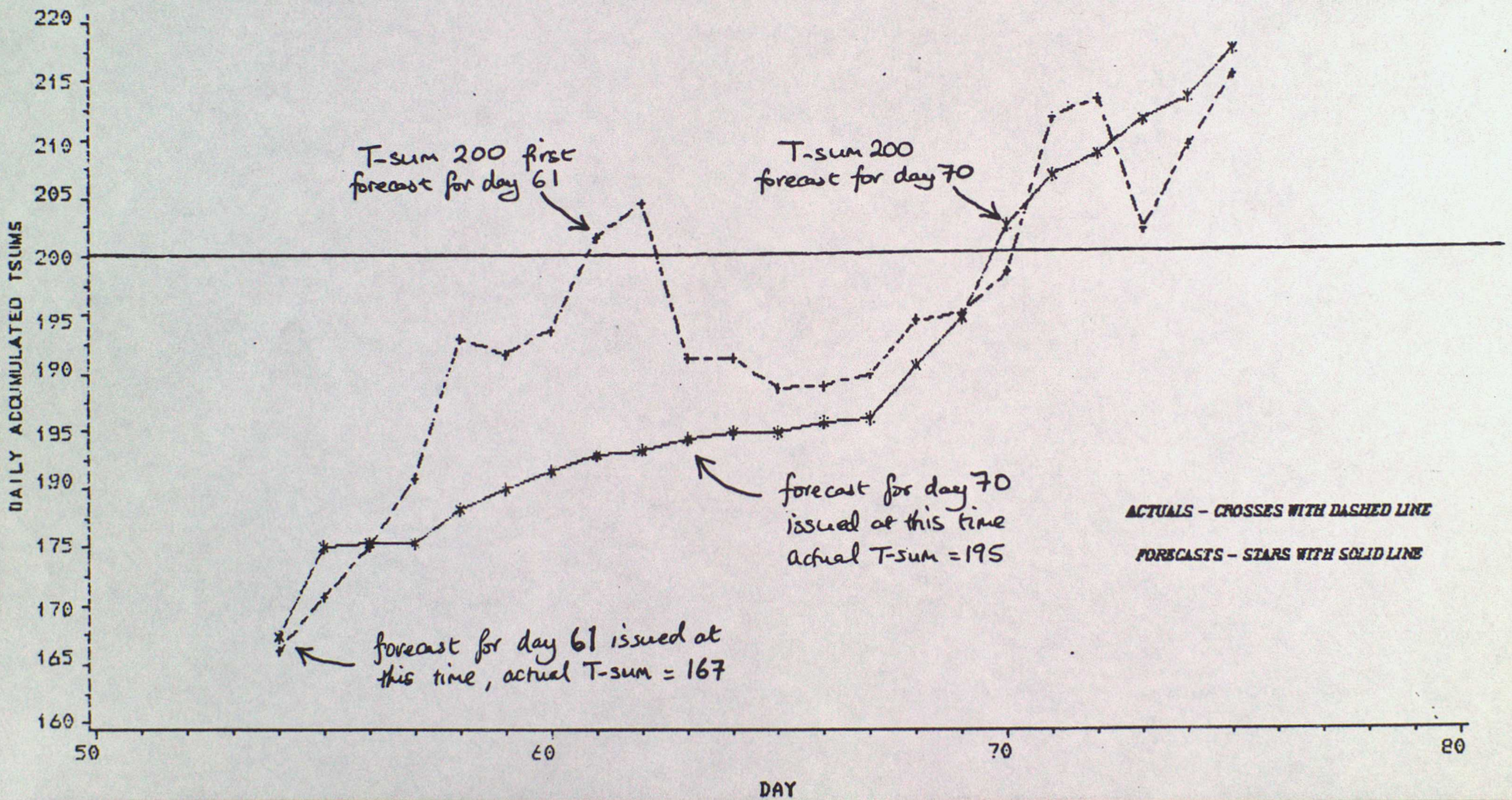
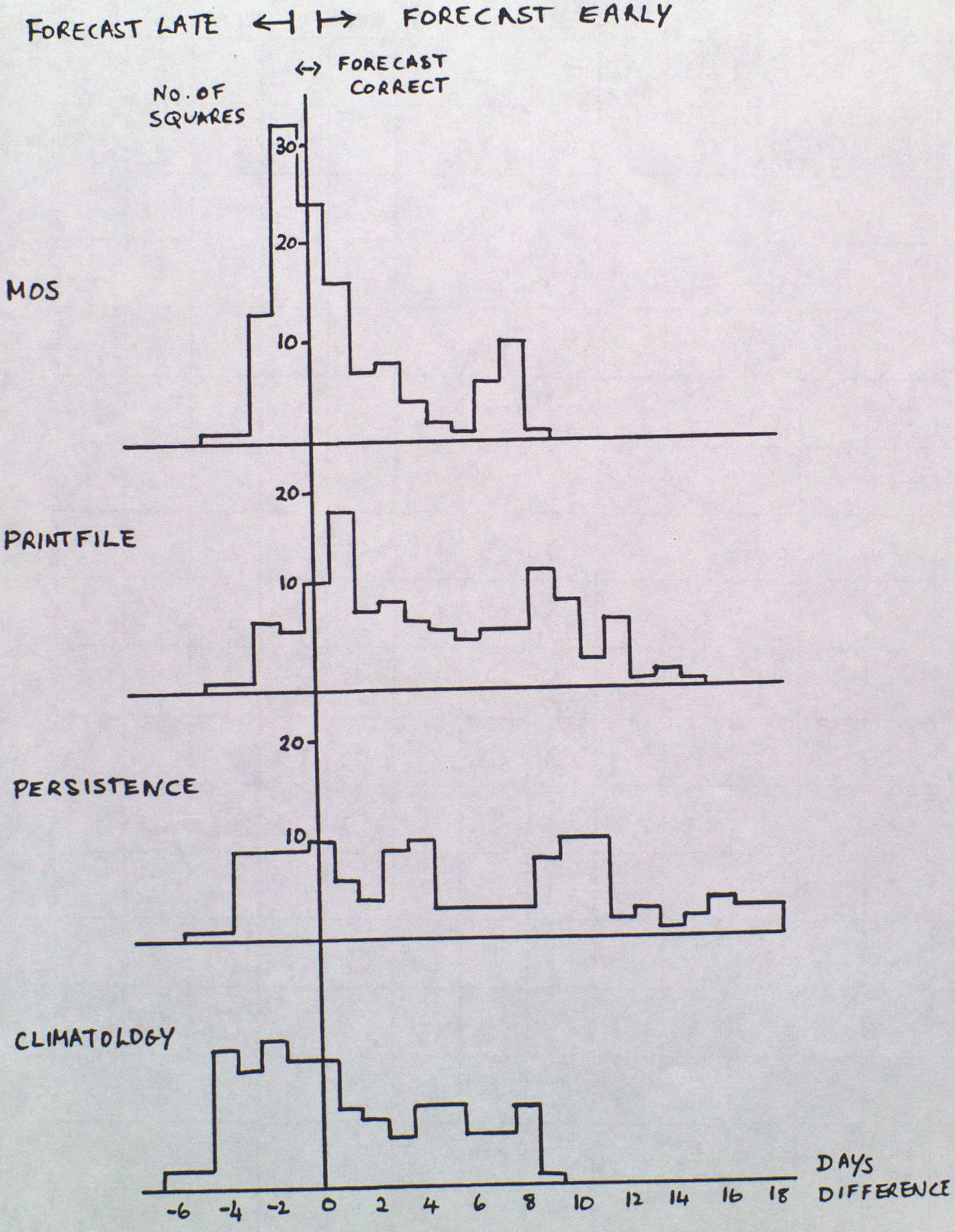


FIGURE 10 SUMMARY OF ERRORS IN DAILY FORECAST T-SUM 200



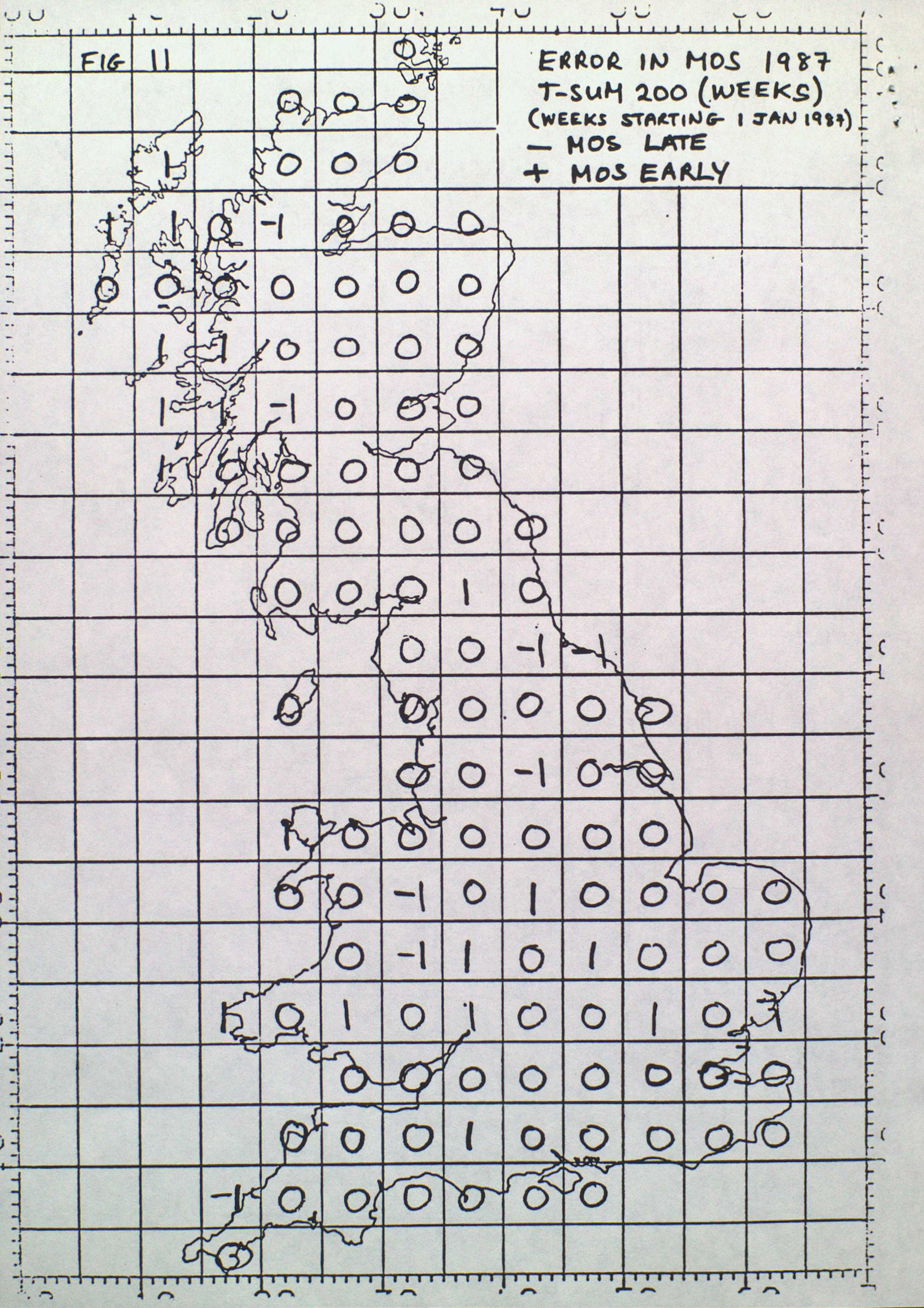
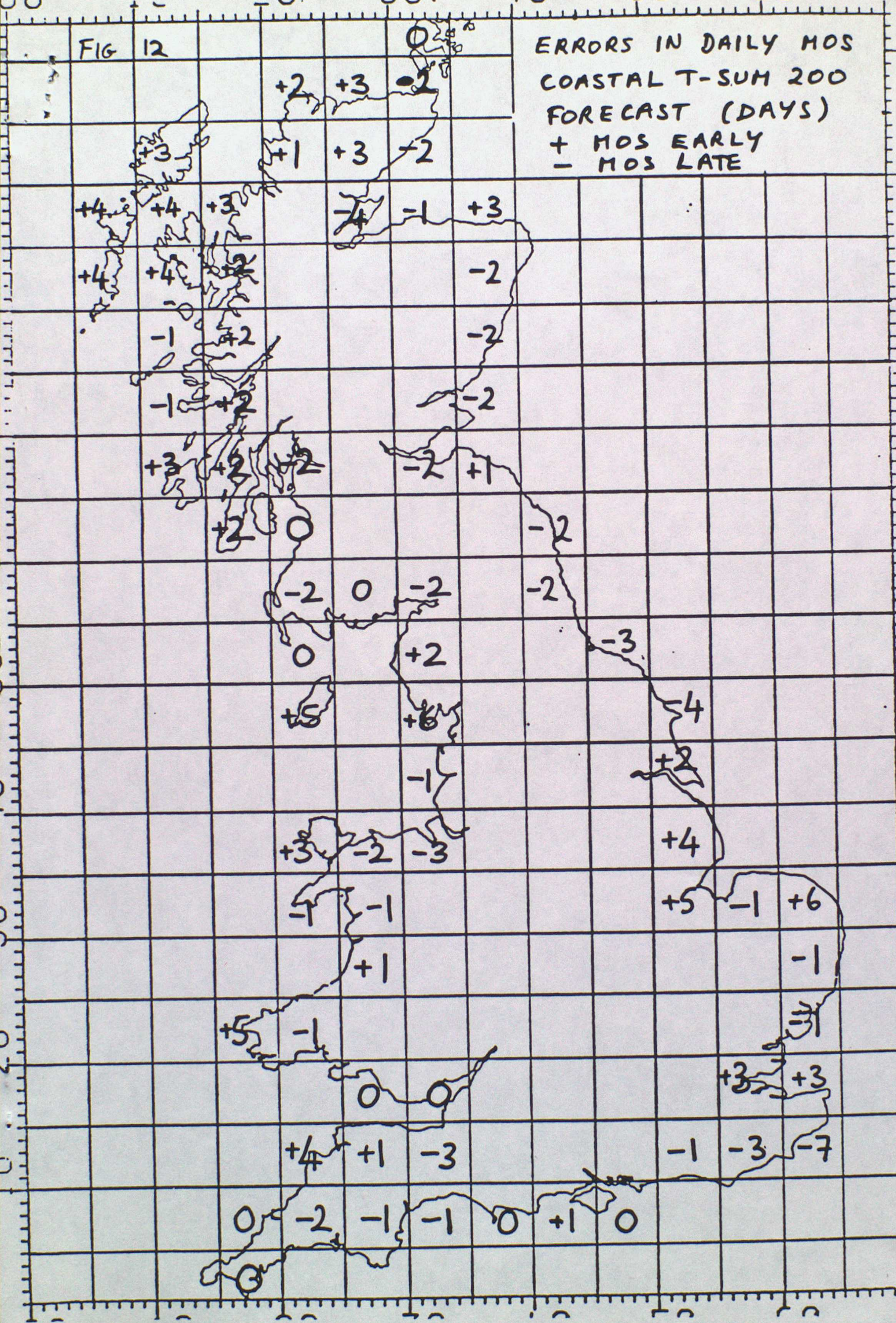


FIG 11

ERROR IN MOS 1987
T-SUM 200 (WEEKS)
(WEEKS STARTING 1 JAN 1987)
— MOS LATE
+ MOS EARLY

0
0 0 0
1 0 0 0
1 1 0 -1 0 0 0
0 0 0 0 0 0 0
1 1 0 0 0 0
1 1 -1 0 0 0
1 0 0 0 0 0
0 0 0 0 0 0
0 0 0 1 0
0 0 -1 -1
0 0 0 0 0 0
0 0 -1 0 0
1 0 0 0 0 0 0
0 0 -1 0 1 0 0 0 0
0 -1 1 0 1 0 0 0
1 0 1 0 1 0 0 1 0 1
0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0
-1 0 0 0 0 0 0
0

FIG 12


0
+2 +3 -2
+3 +1 +3 -2
+4 +4 +3 -4 -1 +3
+4 +4 +2 -2
-1 +2 -2
-1 +2 -2
+3 +2 +2 -2 +1
+2 0 -2
-2 0 -2 -2
0 +2 -3
+5 +6 -4
+2
-1
+3 -2 -3 +4
-1 -1 +5 -1 +6
+1 -1
+5 -1 -1
+3 +3
0 0
+4 +1 -3 -1 -3 -7
0 -2 -1 -1 0 +1 0
0

ERRORS IN DAILY MOS COASTAL T-SUM 200 FORECAST (DAYS)

+ MOS EARLY

− MOS LATE